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An Illustrated Weekly Journal.

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VOL. CXVIII.—No. 3069.] *LONDON: FRIDAY, OCTOBER 24, 1924.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

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THOMAS HUNT & SONS,
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CONTRACTING ENGINEERS.
DESIGNERS and BUILDERS of all Classes of HANDLING MACHINERY.
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68 ACRES OF GROUND AND BUILDINGS, suitable for works, at Inchinnan, on the main road between Glasgow and Greenock.
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Electric power is laid into each of these buildings from the Clyde Valley Power Station, also water supply.
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Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 2357
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FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM and GAS KETTLES } Row's PATENTS.
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See Advertisement, page 27. 1872

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FOR SHEET AND PLATE WORKING.
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Exceptionally Fine 18 in.
CENTRES SLIDING, SURFACING AND SCREW CUTTING LATHE, by S Irk. On very massive 26 ft. box bedplate. All geared headstock arranged for Motor-drive. Two Compound slide rests.
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Telephone: 302 (Three Lines). Telegrams: "Realize."

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Works: BURNT MILL, near HARLOW, ESSEX.
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MILLWALL, LONDON, E.
GENERAL CONSTRUCTIONAL ENGINEERS. 12:6
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 26, Oct. 17. 2402

Matthew Paul & Co., Ltd.,
LEVENFORD WORKS, Dumbarton. 2212
See Full Page Advt., page 44, Oct. 10

Taylor & Challen Presses
For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER. Foundry, Works and Showrooms: BIRMINGHAM.
See Advert., page 79, Oct. 10. 8195

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DARLINGTON. 2006

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54 & 55, FETTER LANE, LONDON, E.C.4.
62 & 63, LIONEL STREET, BIRMINGHAM, and Principal Provincial Cities and Abroad.

New 530 B.HP. M.A.N.
STATIONARY DIESEL ENGINE with accessories, as delivered from the makers under Peace Treaty, £2500; also Dynamo for same, seen London; also other sizes.—HICK-DIESEL OIL ENGINES LTD., 70, Queen Street, E.C. 4. 2443

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AND PROPULSION PROBLEMS.
Special designs only.
"Circulation Theory."
Akimoff Propeller Company,
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To Save Weight — and Avoid Rust — Employ Aluminium.
Data from British Aluminium Co., Ltd., 10s, Queen Victoria St., London. 2017

The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: C. E. Stromeyer, M.I.C.E.
Founded 1854 by Sir William Fairbairn.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 2008

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Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), Inst. M. & Cy. E., and ALL ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours) Eng. London, Assoc. M. Inst. C.E., Chartered Civil Engineer, M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams., comprising hundreds of successful Students. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to S/11, Trafford Chambers, 58, South John Street, LIVERPOOL. 1443

Civil Service Commission.

FORTHCOMING EXAMINATION:
Probationary Inspectors in the Engineering Department of the General Post Office (17 to 20, with extension for service in H.M. Forces), 20th November. The date specified is the latest on which applications can be received. They must be made on Forms to be obtained, with particulars, from THE SECRETARY, Civil Service Commission, Burlington Gardens, London, W. 1. F 889

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 2431

Engineering Drawing.—

Special Postal Course in Engineering Drafting. Enrol now. Fee Three Guineas for the complete course. Also day tuition in Office by qualified teacher. Established in 1895.—PERCY PITMAN, M.I.Mech.E., 25, Victoria Street, London, S.W.1. 2297

Structural Engineering.—A

Civil Engineer gives a course of instruction by correspondence in the calculation of stresses in Beams, Columns and Trusses.—Address, G 164, Offices of Engineering.

TENDERS.

TYNE IMPROVEMENT COMMISSION.

BOILER FOR HYDRAULIC ENGINES.

The Tyne Improvement Commissioners are prepared to receive

Tenders for the Supply and

DELIVERY of a BOILER, about 8 ft. 10 in. diam. by 15 ft. 6 in. in length for their Hydraulic Engine House at Albert Edward Dock, North Shields.

Copies of the Form of Tender, Conditions of Contract, Specification and Drawing may be obtained on application to the undersigned on payment of a deposit of £1, which will be returned on receipt of a *bona fide* Tender.

Tenders, in sealed envelopes endorsed on cover "Tender for Boiler for Hydraulic Engines" must be addressed to "The Chairman, Docks Committee," and delivered at the undermentioned Offices not later than Noon on Thursday, the 30th day of October, 1924.

The Commissioners do not bind themselves to accept the lowest or any Tender.

By Order,
ALBERT BLACKLOCK,
Secretary.

Tyne Improvement Commission Offices,
Bewick Street,
Newcastle-upon-Tyne.
17th October, 1924. G 162

COUNTY BOROUGH OF CROYDON.

TRAMWAYS DEPARTMENT.

TO MANUFACTURERS OF ELECTRIC TRAMCAR BODIES, TRUCKS, ELECTRICAL EQUIPMENTS, etc.

Notice is Hereby Given that the Council are prepared to receive

Tenders for the Manufacture,

SUPPLY, DELIVERY and MAINTENANCE of:

(A) 30 Complete Bodies for Electric Tramcars.
(B) 30 Complete Sets of Maximum Traction Bogie Trucks for Electric Tramcars.
(C) Magnetic Truck and Wheel Brake Equipments for 30 Electric Tramcars, and
(D) 30 Complete Sets of Electrical Equipments for Tramcars together with the assembly of 30 car bodies, sets of trucks, electrical equipments and brakes into complete tramcars in readiness for service operation.

Specifications, Forms of Tender and other particulars may be obtained on application to the Tramways Manager, Tramways Offices, Thornton Heath, Surrey, on and after the 25th day of October, 1924, upon payment of a fee of £2 for either (A), (B), (C) or (D). The fee will be returned to the Tenderer provided he shall have sent in a *bona fide* Tender and shall not have withdrawn the same.

Particulars of the work may be obtained on application at the Tramways Offices previously to the payment of fees for the Specifications, etc.

All drawings referred to in the specifications may be inspected at the above named address on weekdays between the hours of Ten a.m. and Twelve Noon and Two p.m. and 4 p.m. (Saturdays excepted) on production of a copy of the specification concerned or an official receipt for the fee paid therefor.

Tenders on the prescribed form to be sent to me by Ten o'clock in the forenoon of SATURDAY, the 22nd day of November, 1924.

Tenders will only be received subject to the terms of the draft contract deposited at my Office, which may be inspected during office hours.

The Council will not be bound to accept the lowest or any Tender.

JOHN M. NEWNHAM,
Town Clerk.

Town Hall, Croydon,
October 22nd, 1924. G 181

The Director-General,

India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E.1, REQUIRES:—

OIL TANK WAGONS.

Tenders due on the 13th November, 1924.
Tender forms obtainable from above. G 199

BURGH OF FINDOCHTY.

FINDOCHTY HARBOUR EXTENSION.

The Town Council - Hereby

intimate that the TIME for lodging TENDERS is EXTENDED to 3rd NOVEMBER.

WM. SMITH, Solicitor, Buckie,
Town Clerk. G 207

THE DIRECTOR-GENERAL, INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, London, S.E.1, invites

Tenders for the Supply

of:—

1. A 39 in. SELF PROPELLING SUCTION DREDGER, minimum discharge 1500 cubic yards per hour, and Floating Pipe Line of 4500 feet.
2. TWIN SCREW TUG, 80 feet, to operate with above.
3. 12 Sets of DREDGER MOORINGS.

Tender forms will be obtainable on the 27th October, 1924, at the above address. G 200

BOMBAY, BARODA AND CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Friday, 7th November,

Tenders for the Supply of:—

WHEELS & AXLES FOR WAGONS.

Tenders must be made on forms, copies of which, with Specification, can be obtained at these Offices on payment of 10s. each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices: 91, Petty France,
Westminster, S.W.1.
22nd October, 1924. G 202

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,
are prepared to receive

Tenders for the Supply of:—

1. CANVAS.
2. WOOD HANDLES.
3. CEMENT TESTING APPARATUS.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked:—"Tender for Canvas," or as the case may be, must be left with the undersigned not later than Twelve Noon on Friday, the 7th November, 1924.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 5/- for each copy of Specification No. 1, and 2s. 6d. for each copy of Specifications Nos. 2 and 3.

Copies of the Drawings may be obtained at the Offices of the Company's Consulting Engineers, Messrs. Robert White & Partners, of 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W.1.
20th October, 1924. G 201

STATE ELECTRICITY COMMISSION OF VICTORIA.
Melbourne,
Victoria,
AUSTRALIA.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Yallourn Power Scheme.

Copies of Tender Form and Specification will be available upon application to:—

AGENT GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C.2.

SPECIFICATION No. 24/114—
SWITCHGEAR AND ACCESSORIES.

CHARGE:—£2 2s. for the first three copies of Tender Form, Conditions of Contract, Specification and Drawings complete. This charge will be returned on receipt of a *bona fide* Tender. A fourth copy and any further copies will be supplied for the sum of 10s. 6d. each. This charge is not returnable.

PRELIMINARY DEPOSIT:—A Preliminary Deposit of £100 is to be lodged with Tender.

The Specification may be inspected at the above mentioned office.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed form, properly endorsed and addressed must be delivered to the undersigned in Melbourne not later than Noon, 20th December, 1924.

R. LIDDELOW,
Secretary. G 179

EPSOM URBAN DISTRICT COUNCIL.

WATERWORKS.

NEW BORING.

The Epsom Urban District Council are prepared to receive

Tenders for the Sinking of a

BORING, with Lining Tubes 30 inches in diameter, at the Waterworks, East Street, Epsom.

Contractors, desirous of tendering may obtain copies of the Specification, General Conditions, and Form of Tender from the Office of Mr. W. Vaux Graham, M.Inst.C.E., 5, Queen Anne's Gate, Westminster, S.W.1, on payment of the sum of Two Guineas, which will be returned on receipt of a *bona fide* Tender.

Tenders, endorsed "Tender for New Boring," must be sealed and addressed to the Clerk of the Council, 37, Church Street, Epsom, so as to reach him not later than first post on Monday, 10th November, 1924.

The Council do not bind themselves to accept the lowest or any Tender.

E. G. WILSON,
Clerk.

37, Church Street,
Epsom. G 204

THE GREAT INDIAN PENINSULA RAILWAY COMPANY of 48, COPTHALL AVENUE, LONDON, E.C.2, invite

Tenders for:—

1. STATIONERY, &c. ... ... Fee 2/6
2. COPPER TUBES ... ... ,, 10/-
3. ZINC INGOTS ... ... ,, 2/6
4. EXPANDED METAL ... ... ,, 2/6
5. WOOD HANDLES ... ... ,, 2/6

Tenders are due by Eleven a.m. on 4th November, 1924. Tender Forms obtainable at above address. Fees not returnable. G 206

APPOINTMENTS OPEN.

TECHNICAL COLLEGE, BRADFORD.

Applications are Invited for

the APPOINTMENT of ASSISTANT LECTURER in the Department of Civil Engineering, Architecture and Building.

An inclusive salary up to £300 (less the voluntary contribution of 5 per cent.) per annum will be paid to a candidate of suitable qualifications and experience. Candidates should possess a good degree in Civil Engineering, and have had practical experience in public works and buildings.

Full particulars of the appointment, and forms of application, may be obtained from the Principal of the College.

Applications, endorsed "Assistant Lecturer at College," should be sent to me not later than 31st October, 1924.

N. L. FLEMING, Town Clerk. G 183

ROYAL AIRCRAFT ESTABLISHMENT.

A Vacancy Exists for a

RESEARCH ASSISTANT in work relating to Aero Engines. Candidates must have a University Honours Degree in Science or Engineering, or its equivalent, and must have had subsequent experience in engineering works. Age should not exceed thirty years. Commencing salary £250 a year plus Civil Service Bonus (giving present total of £360), on scale £250-20-£350, plus bonus.—Full particulars, with copies of references, should be sent (quoting Reference No. 37) stating age, experience, etc., to the SUPERINTENDENT, Royal Aircraft Establishment, South Farnborough, Hants. G 194

Applications are Invited

for the Vacant POST of TECHNICAL ASSISTANT at the Admiralty Research Laboratory, Teddington. Candidates must be natural-born British subjects and preference will be given to ex-service men. The qualifications required are a sound theoretical knowledge of electrical engineering and some experience in experimental or research work. The salary attaching to the post is £140 10s. to £190 per annum plus Civil Service bonus. The present value of £140 equals £225 7s. per annum.—Applications should be made to the SUPERINTENDENT, Admiralty Research Laboratory, Teddington, not later than the 30th October, 1924. G 151

Test Assistant with

Technical training to the standard of B.Sc. degree and works and drawing office experience, REQUIRED at the ROYAL AIRCRAFT ESTABLISHMENT in connection with checking by calculation the strength and aerodynamic characteristics of aeroplanes. Starting salary 60s. per week, plus Civil Service Bonus, giving present total of 94s. 11d. p.w. Ex-service man preferred.—Apply, quoting A. 33, to SUPERINTENDENT, R.A.E., South Farnborough, Hants. G 195

Works Manager in Engin-

eering Works, 35 to 40 years of age. Thoroughly practical and with good modern shop experience in manufacture of heavy type machinery, 250 to 300 work-people employed.—Address with full particulars of experience and copies of testimonials, stating age and salary required, G 163, Offices of Engineering.

Rate Fixer Wanted in South

of England, must have had wide experience in fixing piece work prices for machinery, fitting and erecting all classes of engine work. Only those with proved experience need apply.—Write, stating age, salary required and where experience gained, BOX 1948, Sells' Advertising Offices, Fleet Street, E.C.4. G 170

Wanted, Experienced

ENGINEER with thorough knowledge, commercial and technical, of air preheating, forced and induced draught, and ventilation. Salary and commission on turnover. Knowledge of French essential.—Address, G 161, Offices of Engineering.

Assistant Engineer,

accustomed supervise erection, running and maintenance of Contractors' or steelwork plant. Long hours, go anywhere, tactful with labour. None but men with necessary knowledge, self-confident, capable of hard sustained work need apply. B.O.T. certificate man might suit.—Address, full particulars, G 205, Offices of Engineering.

Executive Engineer

REQUIRED by the GOVERNMENT of SIERRA LEONE, in the PUBLIC WORKS DEPARTMENT, for two tours of not less than 12 nor more than 18 months' continuous residential service. Salary £600 a year. Free quarters and passages, and liberal leave on full salary. Candidates, age 28-35, should have served articles with a Member of the Royal Institute of British Architects, and have passed the examination qualifying for Associate Membership of that Institute, or possess the diploma of some recognised college which is accepted by that Institute as exempting candidates from taking the examination of the Institute. Must be a first-class Draughtsman, capable of designing and carrying out buildings, taking out quantities, preparing details and Specifications, and must be competent to execute building surveys, set out buildings and lay out roads. Other qualifications being equal, preference will be given to candidates who have had experience of the work of a Civil Engineer in the construction and carrying out of general public works.—Apply at once by letter, stating age, qualifications and experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W.1, quoting M/13190. G 198

Wanted Engineer for Charge

of repair shops, running sheds and motormen on Electric Railway in London. Only those with previous experience of similar work should apply, stating age and giving particulars of education, experience, and salary required.—Address, G 190, Offices of Engineering.

Aerial Ropeways.—Firm

Specialising in Aerial Ropeways REQUIRES the SERVICES of a Thoroughly Experienced ENGINEER to take over the management. Applicants must be able to supervise estimating and constructing of Ropeways and Transporters of all kinds, and only men with previous specialised experience, details of which should be given, need write.—BOX 1968, Sells' Advertising Offices, Fleet Street, E.C. 4. G 213

Civil Engineer Required

for Government Department, in connection with Airship Shed and Mooring Mast at Cardington.

Candidates must have served in H.M. Forces during the war, should preferably be Associate Members of the Institution of Civil Engineers, and have had good training and experience in connection with large steel structures. The salary offered will be from £560 to £680 a year, inclusive of Civil Service bonus, according to qualifications.

Written application with full details of experience, qualifications, age and salary required, should be addressed to the JOINT SUBSTITUTION BOARD, Montagu House, Whitehall, S.W.1. G 196

Wanted, Working Charge-

HAND for Heat-treatment Department in Motor Vehicle Works. State age and wages required.—Address, G 192, Offices of Engineering.

First-class Machineman

MECHANIC REQUIRED, Derbyshire district.—Address, stating age, experience and wages required, G 215, Offices of Engineering.

Wanted, First-class Engin-

eering STOREKEEPER in large works employing upwards of two thousand men. Only first-class men need apply.—Address, G 216, Offices of Engineering.

Draughtsman Wanted for

designing office of large marine engineering works on Clyde. Must have first-class technical education and sound experience in Diesel Engine Design. Send full particulars, experience, age, and salary expected.—Address CLYDE,
Wm. Porteous & Co.,
Advertising Agents, Glasgow. G 177

Draughtsman, Mechanical,

WANTED, Wembley, at once for a few weeks; make detailed plans of existing plant. Write stating age, experience, salary required and enclose copies of references to CONSULTANT, c/o Streets, 6, Gracechurch Street, E.C.3. G 178

Draughtsman, Fully Qualified

in Structural Steelwork and Mechanical Engineering. Experience in elevating and conveying machinery would be an advantage.—Apply, giving full particulars to BOX E, Messrs. W. H. Smith & Son, Wolverhampton. G 168

An Experienced Railway

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ROLL BEARINGS FOR COLD ROLLING MILLS.

By C. E. Davies, A.M.I.Mech.E.

The intention in writing this article is to review and compare the various designs, materials and lubrication systems for cold roll bearings in general use in this country and abroad. The subject has already received considerable attention from rolling mill engineers and mill managers, with the result that the modern roll bearing is generally more intelligently designed than was the case a decade ago. Unfortunately, a generally accepted standard for design, material, &c., is still far from being realised, and there exists a great divergence of individual opinion. Individuality, within limits, is an excellent thing and no engineer or mill manager can be blamed for retaining a design, or particular grade of metal, which has been proved to suit his particular requirements, in spite of the fact that his neighbour or foreign competitor adopts an entirely different type of bearing. At the same time, there is no doubt a particular design, quality of bearing metal, and lubrication system, which would best comply with average conditions of working, and which with very slight modification would give the best results under all circumstances.

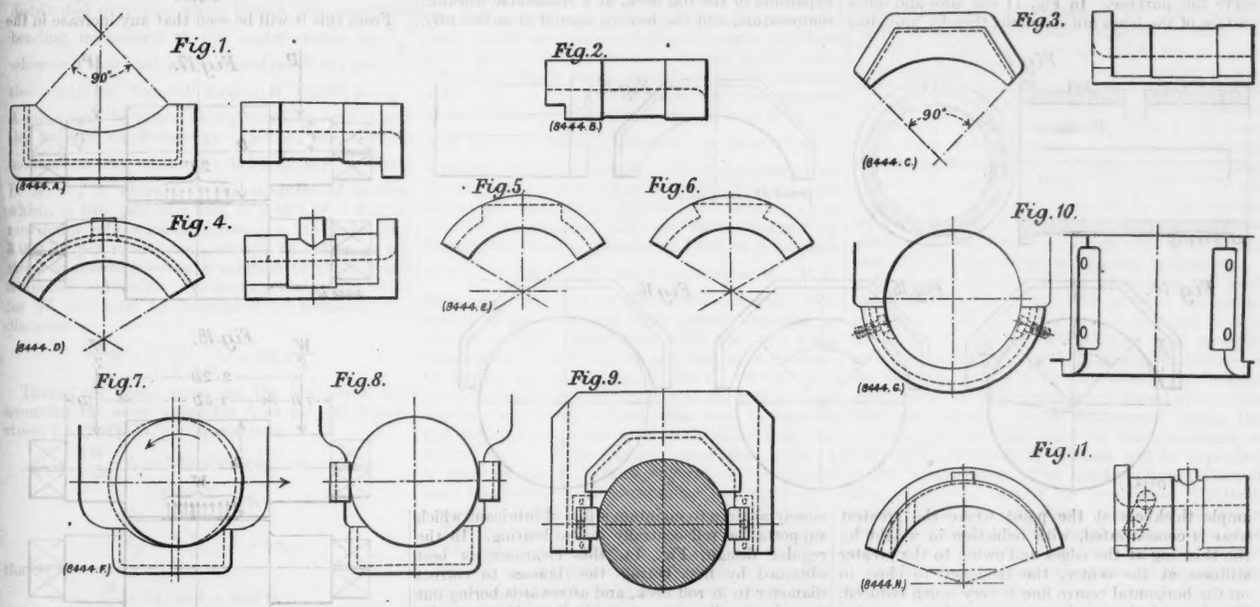
The roll bearing is without doubt the part of the mill which requires the greatest attention and its successful operation under heavy loads makes for both economy and accuracy of product. No bearing in any other class of machine has to work under more arduous conditions. The pressure per unit area of bearing surface is considerably higher than the limit set by engineers for bearings in other machinery. The load is always in one direction and generally continuous for considerable periods with very short intervals of rest. The difficulty in protecting the bearing surfaces from dirt and grit, and at the same time providing for efficient cooling, is in itself a serious handicap. Bearing pressures on the roll neck may be anything from 800 lb. to 3,000 lb. per square inch of bearing surface, and with such pressures the maintenance of a film of oil, between journal and bearing is almost impossible, with the result that hot bearings are a continual source of trouble in any cold rolling mill, and loss of power in bearing friction, with rapid wear of brasses, is inevitable. Fortunately, the surface speed of cold roll bearings is comparatively low, although this advantage is now not so great, owing to the tendency to increase roll speeds, and with the high speed mill, the question of roll bearing design requires still more serious consideration. The power absorbed by the four bearings supporting a pair of rolls is sometimes as much as 90 per cent. of the total power applied to the mill, and is rarely less than 40 per cent. The whole of this lost power is converted into heat, and must be dissipated at a rapid rate if the bearings are to be kept within reasonable limits for temperature.

The subject may be considered under three heads:—(1) Design; (2) Material; (3) Lubrication and cooling. These three questions are to some extent interdependent, and the first named cannot be fully discussed without involving consideration of the other two.

Design.—It is not now necessary to give attention to the types of bearing usually fitted to mills in the early days of rolling, when neither the bearings, nor the recesses for them in the roll frames and chocks were machined, but it may be remarked that the earlier forms of roll "brass" and even some designs still favoured, were adopted, more because they required the minimum of fitting and machining than that they had any claim to efficiency. This form of bearing is illustrated in Fig. 1 and is still employed by some mill engineers. It had the merit of being simple in form, easy to machine, and was frequently fitted into place by hand chipping and filing, the only portion machined being the bore. Considerable skill and time was required to fit a set of brasses if reasonable accuracy of alignment was required. The brass did not bear over the whole surface of the recess in the chock or roll frame, but was provided with chipping strips to facilitate the work of fitting. Its plain flat base was also favoured because it allowed for packing up worn brasses; actually, there is very little advantage in this, and the necessary attention to packing to ensure accurate alignment was rarely given. These flat brasses are also relatively expensive as the weight of brass, for any given size is considerable, and a large proportion of the weight (at the corners) is unnecessary. The next design, Fig. 2 is a simple modification of that shown in Fig. 1 and differs only in longitudinal section, the flange in the first type being omitted and a step formed in its place, to prevent end movement. This shape is, however, not convenient when brasses and seating are properly machined, as it is difficult to machine the seating in its housing due to the projecting ledge required. The only advantage which could be claimed for it is that the brass is supported right up to the end of the roll barrel, this is, however, a very doubtful advantage, especially as it is scarcely possible to ensure bearing on the radius at junction of the roll and roll neck; in fact, a bearing on the radius is undesirable.

The brass shown in Fig. 3 was introduced more particularly as a top roll bearing, *i.e.*, fitted in the chock, presumably on account of the saving in weight of metal over the flat type (Figs. 1 and 2), and the possible need for packing up the brass does not, of course, arise in the case of the top roll bearing. Figs. 4 and 5 show an entirely different type of brass, which was introduced about 15 years ago, and was fitted to some strip rolling mills at that time. This design has many advantages. While the useful thickness of metal in the line of pressure is maintained, the circular form eliminates the redundant metal in the corners of the designs previously described. The circular form is much easier to machine not only in the case of the bearing, but also in that the seating in roll housing and chock, which could be bored. Spigots or keys (as Figs. 5 and 6) have to be provided to prevent the brass turning in its seat; with the former, convenient machining of the outside of the brass can be easily accomplished, but with the keyed design this machining is more difficult and costly. The dovetailed form of key in Fig. 6 serves to hold the brass in the top chock, but seems to be scarcely necessary.

It should be noted that the designs so far described do not, as a rule, provide a complete semi-circular bearing, the bearing being usually not more than one-third of the circumference. Many mill engineers still favour these designs on this account, and have certain grounds for holding their opinion. As is well known from experiments on bearing friction, there is less frictional loss in a bearing which embraces only a small segment of the circumference, than in one which covers the complete half-circle. The centre 90 deg. of arc (45 deg. on either side of the vertical centre line) is obviously more efficient in supporting the bearing load than the remaining portion of the semi-circle on either side, and in that case a great part of the roll neck is exposed to the cooling effect of the atmosphere and the water, which is directed on to the bearings to carry away the heat generated by friction. The small arc bearings have, however, certain grave disadvantages, for while exposing the roll neck to facilitate cooling, equally free access is given to dirt and grit which are usually much in evidence in a rolling mill. Also, very little support is given to the roll in the horizontal direction, and there is a very great tendency for the bearings to wear on one side as shown by Fig. 7, this wear resulting in bad alignment of rolls, a serious trouble especially with long rolls. For this reason large sheet rolls, with this type of bearing are usually provided with side brasses, shown in Fig. 8. These brasses are simply flat strips of gun-metal, and are packed up to compensate for wear. Side brasses are, however, not entirely successful, unless they receive careful attention and are frequently adjusted both horizontally and vertically. A design of bearing with side brasses for large sheet rolls, is shown in Fig. 9 where they are carried in the chocks and are provided with wedge adjustment. For strip mills, side brasses are a disadvantage and are best avoided, especially as the advantages of a small arc bearing can be



obtained, with a fully semi-circular brass which affords ample support to maintain the correct alignment of the rolls.

The circular form of bearing, but covering completely, or very nearly completely, the full half-circle, is obtained in the designs shown by Figs. 10 and 11. The former is an American design, and shows set screws securing the sides of the brass to the seating. These serve to prevent the brass turning, and also to prevent the closing in of the sides, when the bearing is under pressure and has become heated. This last point calls attention to the dangers with large arc bearings and especially with those of the circular type, owing to the well known tendency of such brasses to close in and nip the shaft on the horizontal centre line. Also, if the brass fits tightly to the neck over the whole half-circle, it is extremely difficult to get lubricant to the part of the bearing under greatest pressure. On this account it is good and general practice in high speed motor and other bearings to provide a recess at the sides, as shown by Fig. 12. These recesses form a collecting chamber for lubricant and also minimise the pressure on the sides of the journal. In Fig. 10 the recess for securing screws serve this purpose. In Fig. 11 the bore and outer surface of the brass are eccentric, thereby providing

Fig. 12.

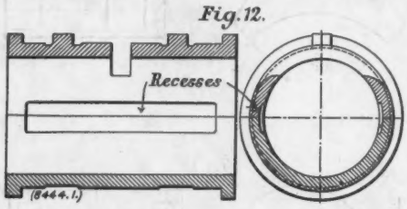


Fig. 13.

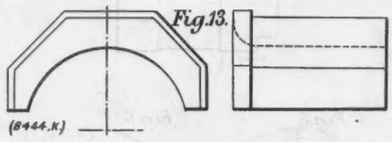


Fig. 14.

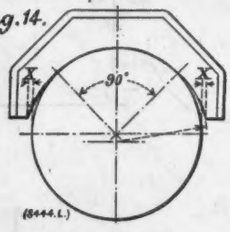


Fig. 15.

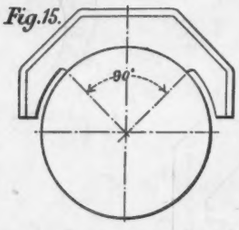
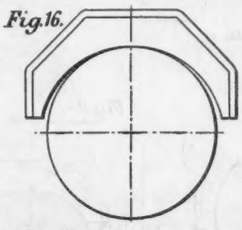


Fig. 16.



ample thickness at the point where the greatest wear is concentrated, with reduction in weight by the thinning at the edges and owing to the greater stiffness at the centre, the tendency to close in on the horizontal centre line is very much reduced. The eccentric form is however somewhat expensive to machine.

The next design, shown in Fig. 13, resembles Fig. 3 in cross section, and is adopted very generally, with slight variation in proportions in modern high-grade cold rolling mills. The arc covered by the bearing is very nearly a complete semi-circle. The outer surface is octagonal in cross section, thus approaching the circle in economy of material. The inclined sides of the octagon (at 45 deg. with the base) provide for easy adjustment of fit sideways, while the vertical sides do not require close fitting, as a good bearing on the flat bottom and inclined sides is all that is necessary. With ample thickness on the vertical centre line, and a reduced thickness at sides, the danger of closing in under pressure is minimised. From the manufacturers point of view, though naturally more expensive than the earlier forms of flat brass, both in material and machining costs, this design is not unduly expensive in comparison with any of the later designs for properly machined brasses, and can be made a good fit in the seatings without much hand work. Interchangeability can easily be obtained, and spare brasses for renewals can be supplied which require very little fitting on site. It is very difficult to improve on the general form of this bearing, which is becoming more and more popular with mill designers and users in this country and abroad. The only objection from the users point of view is that the arc of contact is greater than the length of circumferential contact still preferred by some. However it can be shown that correct machining closely at sides to maintain a film of lubricant which supports the roll centrally in the bearing. In the regular design, Fig. 14, this clearance is best obtained by first boring the brasses to correct diameter to fit roll neck, and afterwards boring out to a larger diameter eccentrically. Alternatively, the clearance can be scraped out, after boring to size, but it is preferable to machine a definite clearance as described, rather than trust to hand scraping. The eccentric bore leaves a gradually tapering clearance which assists the feeding of oil to the bottom of the bearing. The only fitting then required is the scraping of the 90 deg. of actual bearing surface. This should be carefully done to ensure a regular and even bearing for the neck over this arc of contact. Approximately the same result is obtained by simply boring the brasses to a diameter somewhat larger than the roll neck, giving the result shown by Fig. 16. This is a very common practice, but while it is desirable to bore the brass, in any case, slightly larger than the neck of the roll, an increase in diameter sufficient to give the necessary side clearance would call for an excessive amount of hand scraping, to obtain a good bed for the neck over the required bearing arc. The amount of side clearance required, X, Fig. 14, may be varied to suit working conditions, but should not be less than 0·001 in. per inch of roll neck diameter. In addition it is desirable to provide a chamfer at the edge of the brass to collect lubricant, and ensure an ample supply of oil to the clearance space. As previously mentioned, the radius at the neck should not bear on the brass, and it is advisable to make the radius of the brass definitely larger than the radius of the roll.

Apart from the detail design of roll bearings, the question of diameter and length must be considered. Of late years there has been a progressive tendency to increase the diameter of the neck in relation to the size of the roll barrel, and the ratio of neck diameter to roll diameter has increased from about 0·6 to 0·7 and even 0·8. On general principles a relatively large diameter reduces the intensity of pressure on the bearing surface and is consequently to be recommended, but obviously a limit must be fixed, otherwise there is no reason why the ratio should not be increased to 0·95, that is, making the neck very nearly as large as the roll itself. It is often difficult for managers of rolling mills, who are not engineers to understand that the increase in size of neck with any given barrel diameter, carries with it a disadvantage; for, naturally, the greater the neck diameter the greater is the friction loss, other conditions remaining the same. Referring to Fig. 17, taking the total load on the bearing as P, the frictional loss per revolution

$$= \frac{P \mu 2 \pi r}{12}.$$

where μ represents the coefficient of friction, and r is the radius of the neck in inches. The horse power lost in the four roll bearings is therefore

$$= \frac{P \mu r N}{15,750}$$

From this it will be seen that any increase in the

Fig. 17.

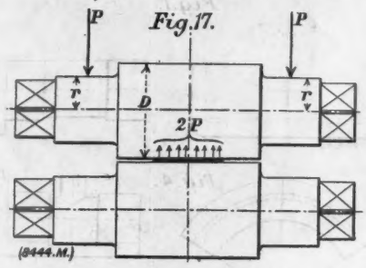
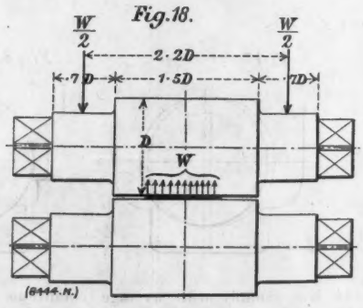


Fig. 18.



diameter of roll neck will result in a proportionate increase in frictional losses, providing, of course, that the coefficient of friction is unaltered, and that the projected area of bearing is not too small for the load. This bearing area is the product of diameter and length and must be sufficient to keep the intensity of pressure below the limit at which the lubricant is squeezed out and actual metallic contact occurs, as this would cause a very considerable increase in friction, and probably also damage to the bearing surfaces. As the diameter should be kept small to reduce loss in friction to a minimum, the bearing area might be maintained to the necessary dimensions by increasing the length of bearing, the diameter being settled on considerations of strength only. As with other bearings, the general principle of keeping down the diameter to a size which will have sufficient strength and increasing the length to give ample bearing area holds as well in the case of roll bearings, but the proportion of length to diameter, which may be as much as four in ordinary bearings, must be much less in those for a rolling mill. In the opinion of the writer, mill designers have erred to some extent by increasing the diameter of roll necks without extending the bearing length as much as they might. The very heavy pressures used on roll bearings preclude the adoption of great length owing to the tendency of the load to cause bending in the roll neck itself and the concentration of the pressure on the inside of the bearings. This danger might be minimised by

providing self-aligning brasses with spherical seatings, but these do not seem to have been tried. There would still remain a possibility of trouble, owing to the increase in the distance between the effective centres of roll supports, and the consequent heavy bending stresses in the roll barrel. For these reasons, the length of roll bearings does not usually exceed the diameter of neck and is more usually about 0·95d., or, in terms of roll diameter, 0·7 to 0·65 D.

The desirable proportions for roll necks can be obtained very closely by calculation. Referring to Fig. 18, which shows diagrammatically the loading of a roll, with dimensions in terms of the roll diameter D; assuming an average length of roll barrel as 1·5 D and length of roll bearing as 0·7 D, the distance between centres of supporting bearings will be 2·2 D. The load on a roll in a cold rolling mill may be distributed over practically the whole of its length (as in sheet rolls), but the worst conditions probably occur in a strip mill, where the load is concentrated over a length equal to about half the total length of roll barrel or less, and the centre of the loaded length coincides with the centre of the length of the roll barrel. If the load W were distributed over the whole length the maximum bending movement at the centre would be $\frac{W\,L}{8}$ whereas if this load were concentrated at a point at the centre of the roll length it would be $\frac{W\,L}{4}$. A mean may be taken as representing very closely the average conditions in practice; the bending moment at the centre of roll being, say, $\frac{W\,L}{6}$ and B. M. $= f\,z$, where z = the modulus of section, which, in the case of a roll, $= 0{\cdot}098\ D^3$. For the maximum safe working stress f, a low value, say 3,000 lb. per square inch, should be taken, as the stress is reversed every revolution of the roll and is applied suddenly. An average maximum value for W can now be calculated in terms of roll diameter :—

$$W = \frac{0{\cdot}588\ D^3 \times f}{2{\cdot}2\ D} = 800\ D^2$$

Taking the shear stress on the roll necks and assuming the same value for f_s as for the tensile stress, *i.e.*, 3,000 lb. per square inch,

$$\frac{2\,W}{\pi\,d^2} = f_s = 3{,}000 \text{ lb. per sq. inch}$$

$$\therefore \quad \frac{1600\ D^2}{\pi\,d^2} = 3000$$

$$\therefore \quad \frac{D^2}{d^2} = \frac{\pi \times 3{,}000}{1{,}600} = 5{\cdot}9,$$

that is

$$\frac{D}{d} = 2{\cdot}4\text{; or } d = 0{\cdot}42\ D.$$

Calculating the possible maximum B.M. at the junction of roll neck with barrel :—

$$\text{B.M.} = \frac{W}{2} \times 0{\cdot}35\ D = 0{\cdot}038\ d^3 f$$

$$\therefore \quad 400\ D^2 \times 0{\cdot}35\ D = 0{\cdot}098\ d^3 \times 3{,}000$$

$$\therefore \quad \frac{d^3}{D^3} = \frac{140}{294} = 0{\cdot}475$$

and $$d = 0{\cdot}78\ D.$$

Again, limiting the bearing pressure to 1,000 lb. per square inch,

$$\frac{\frac{1}{2}\,W}{d \times l} = 1{,}000$$

$$\therefore \quad \frac{400\ D^2}{d \times 0{\cdot}7\ D} = 1{,}000$$

$$\therefore \quad \frac{d}{D} = \frac{400}{700} = 0{\cdot}570.$$

To summarise the above results, the ratio of roll neck diameter d to roll diameter D may be determined approximately by calculation, taking (i) the shear strength of neck, (ii) resistance to bending, (iii) bearing area, and the values obtained in the three cases are :—

(i) Diameter necessary to resist shear	$d = 0{\cdot}42\ D$
(ii) Diameter necessary to resist bending	$d = 0{\cdot}78\ D$
(iii) Diameter necessary to give bearing surface sufficient to limit pressure to 1,000 lb. per sq. in	$d = 0{\cdot}57\ D$

While these figures are calculated from an assumed maximum load, they serve to indicate very clearly the factors which must be taken into consideration in determining the correct proportions of the roll neck. Clearly, the shearing stress is relatively unimportant and the diameter should be sufficient to resist the possible maximum bending moment; thus a ratio d/D of about 0·78 should give satisfactory results. This agrees very well with modern practice where d/D varies from 0·7 to 0·8. As the calculations for bending stress are based on the worst possible conditions, *i.e.*, assuming that the load is applied at the centre of the bearing, there would be little fear of breaking the roll at the junction of the neck and barrel, even if the load applied exceeded the assumed value of 800 D^2 lb., and a sufficient margin of strength is available to cope with the torque applied in rotating the roll. As regards bearing area, since the length of bearing is often not more than 0·65 D, the average bearing area would be :—

$$0{\cdot}7\ D \times 0{\cdot}65\ D = 0{\cdot}455\ D^2,$$

and the intensity of pressure on the bearing is :—

$$\frac{400\ D^2}{0{\cdot}455\ D^2} = 880 \text{ lb. per sq. in.}$$

With very short stiff rolls, for heavy work, where the length of the roll barrel is equal to diameter, the maximum load may be as much as 1,040 D^2 and the ratio of $\frac{d}{D}$ should be about 0·85. Similarly, if the roll barrel length is greater than 2D, a smaller neck would be strong enough and a ratio of about 0·65 would be satisfactory. All the above calculations are based on the strength of chilled cast-iron rolls. With hardened steel rolls, while the material is much stronger, the roll is able to bear a heavier load and the ratio $\frac{d}{D}$ obtained by calculation of strength would be the same. The bearing area then becomes the more important consideration and, taking the strength of the steel roll as being twice that of the cast-iron roll, the ratio obtained by limiting the bearing pressure to 1,000 lb. per square inch, $\frac{d}{D} = 0{\cdot}875$ would not be unreasonable. It is, however, very rare to find hardened steel rolls loaded in proportion to their greater strength as compared with chilled iron rolls, and the same dimensions of neck may be adopted in both cases. Generally, an average proportion $d = 0{\cdot}75D$ provides for uniformity of strength of the roll to resist bending, and there is very little need to increase this beyond $d = 0{\cdot}8D$ even with short rolls, for heavy work. These ratios, combined with a bearing length of from 0·65D to 0·7D, should keep the intensity of pressure on bearings within reasonable limits.

The only other important dimension to be fixed in designing roll bearings is the thickness of "brass" at the point of maximum load. This can only be determined by experience, and it is not only a question of providing sufficient thickness to withstand wear, but to give depth enough to prevent deformation of the bearing by the action of closing under load. The thickness of brass, provided in modern roll bearings varies from 0·15*d.* to 0·2*d.* while the values from 0·16*d.* to 0·19*d.* are representative of good practice. In large mills, the smaller thickness is sufficient, but for smaller rolls it is desirable to provide proportionately thicker metal. While a brass in which the thickness has been reduced to a minimum to save cost is bad practice, it is foolish extravagance to put in excessively heavy bearings, as the expense of these items in a large mill is a considerable proportion of the total material cost.

(To be continued.)

ROAD IMPROVEMENTS.

ACCORDING to a pre-war estimate the 235,000 miles of public roads then existing in the country had cost 350 millions to build, and an additional expenditure of 287 millions would have been necessary to fit them for modern traffic. In view of the rise in prices occasioned by the war, this latter figure must now be far from adequate. The economic situation is somewhat peculiar. In pre-war times we should certainly have hesitated to incur our present rate of expenditure on road improvement, but it is not always practicable to determine policy solely by economic considerations, and as matters stand, roads are being built or reconstructed at a more rapid rate than would have been considered judicious, even in prosperous pre-war times. In view of the circumstance that the schemes of which the execution has been hastened, are not mere rapid improvisations, but in many cases represent plans already perfected some years back, there seems every chance that the present heavy rate of expenditure will prove a fairly sound investment, even if less profitable than it might have been, had it been possible to raise the funds required under less onerous conditions. This has not always been the case in the past, when, as to-day, road-making was pushed forward in order to reduce unemployment. Many of the "famine" roads thus constructed in Ireland never came into effective use. In view of Sir Henry Maybury's unrivalled experience there is no possibility of a similar fate overtaking the carefully considered plans now in process of execution.

The capital necessary for the extensive work now in progress is provided in part by motor taxes, which last year yielded over 14,000,000*l.*, and in part by contributions from the local authorities. In the case of first-class roads the general practice is for the Ministry of Transport to contribute 50 per cent. of the approved cost of maintenance and improvement, the corresponding figure for second-class roads being 25 per cent. In Scotland, however, highway rates are in some districts already very high, as long stretches of road run through sparsely-populated areas. Hence, in such cases, the Government grant is increased and may be as much as three-fourths of the total. With the increasing traffic it is very important that the engineers and surveyors appointed by the local authorities shall be really competent, and the attainment of this end is helped by contributions from the Transport Ministry to the salaries of the officials. Such contributions are now made in the case of 1,370 out of 2,200 highway authorities.

As already indicated, a large amount of road work has been hastened in order to mitigate the unemployment problem. This has necessitated a considerable anticipation of the road fund receipts, with the result that the outstanding liabilities of the fund exceed by some 5,000,000*l.* the balance available at the end of the last financial year. The total sum which is to be contributed during the present year to this relief of unemployment is 8,000,000*l.*, of which 2¼ millions will be expended in the London area. The London County Council has, moreover, agreed to contribute 750,000*l.* towards the cost of these works on condition that the unskilled labour employed is drawn that entirely from the administrative county of London.

The schemes in question and the estimated costs of each are as follows :—

	£
(*a*) Crays and Orpington by-pass ...	350,000
(*b*) Watford and Barnet by-passes ...	1,895,000
(*c*) Construction of a viaduct and approaches across the River Lee, near Edmonton	140,000
(*d*) Improvement of road connections between Croydon and Sevenoaks	234,000
(*e*) Bexley Heath by-pass	381,000

The proposed route of most of these improvements is shown in the map, Fig. 1, on page 572, which also sets forth, far more clearly than could be done in words, the progress already made in reconstructing and improving the arterial roads in the Greater London area.

The reconstruction of the old Roman highway known as Watling-street, between Dartford and Strood, has involved some of the heaviest work. It is, of course, notorious that the Romans, excellent road engineers as they were, did not realise the importance of reducing counter-gradients to a minimum; their roads ran nearly straight up hill and down dale. Thus, Watling-street passed over Swanscombe-hill with gradients as high as 1 in 8, and traffic has consequently been diverted to easier, but more circuitous routes. A cutting 72 ft. deep has now been made through this hill, giving a easy and direct route from London to Dover. The length of reconstructed road is about 11 miles. and its width is 100 ft. between fences, but the carriage-way is, for the present, restricted to 30 ft. or 40 ft.

In addition to the schemes indicated on the map, the Ministry of Transport have sketched out a plan for a North Orbital road, of which the construction

can hardly be undertaken for some time, but which it is thought well to put on record, so that town improvements and town-planning schemes in the area affected, shall be laid out, so as to favour rather than obstruct the future execution of the scheme. This road, which will have a total length of some 75 miles, will follow a more or less semi-circular route. Starting at a point east of Tilbury, the road will skirt Brentwood, Ongar, Hoddesden, to Hatfield, whence it will proceed *via* St. Albans and Rickmansworth, to a junction with the Bath-road at Slough. Most of the work involved will consist merely in the improvement of existing roadways.

As indicated, there is no intention of embarking on this scheme at any early date. There is, in fact, much more urgent need for road improvements in the dock area, where road congestion is now extreme. The roads here existing are not only narrow, but the area is intersected by a number of water-ways, in part natural and in part artificial, and the bridges over these are far from adequate for the traffic. Railway level-crossings are numerous and occasion much delay. The need for extensive road improvements has long been manifest, and much further traffic may be expected when the new dock is opened. The local authorities are too poor to do the necessary work themselves, and the requisite funds must be provided from other sources. In the meantime the problem has been thoroughly studied by the Ministry of Transport, who have prepared a scheme for new or improved roads, which we describe below.

As matters stand most of the heavy traffic from London to the docks and the Silvertown factories has to cross the Lea by the Iron Bridge (see Fig. 2), built in 1897. This is but 55 ft. wide between parapets, and not only is the gradient 1 in 29, but there is a sharp curve. Horses are so constantly in trouble in getting over this bridge with their loads that special appliances are held in readiness to assist them. The traffic intensity is stated to be 31,103 tons per 24 hours. Later on, the main stream of traffic has to make its way down Victoria Dock-road with a carriage-way only 21 ft. wide, and then has to swing through a right angle on reaching Barking-road. Here it encounters a level crossing where, owing to the intensity of the rail traffic to and from the docks, the gates are closed for a total of over 9 hours in the 24, and in the busiest part of the day for as much as 47 minutes in the hour.

Throughout the whole area, very similar conditions prevail. In every part narrow carriage ways, level crossings and inadequate bridges are to be met with, the resulting obstruction being such, that fully 35 per cent. of the time spent on a journey is absorbed in delays.

To remedy matters the Ministry of Transport proposes to construct the new roads shown in Fig. 2. Work will start in the East India Dock-road, on the London side of the Lea. This will be widened to 100 ft. The old iron bridge will be removed and replaced by a new one, 100 ft. wide, and having easy approaches on both sides. The Barking-road will be widened to the same width from this new bridge up to the Beckton-road, which will also be similarly remodelled, and will then form an extension of the East Ham and Barking by-pass. By the execution of these works a clear channel will be provided for London traffic to and from the East.

Further works will involve the construction of an alternative to the Victoria Dock-road. The route of the proposed new road is shown in Fig. 2 by the dotted lines running from the Iron Bridge to the North Woolwich-road.

It is proposed that this new road shall be 80 ft. wide, and for a long stretch it will be carried on viaduct, thus avoiding both the obstruction due to the railway level crossings and those arising from traffic issuing from the maze of side streets. The works will involve the construction of a new swing bridge, 60 ft. wide, over the western outlet from the Victoria Docks. The proposed works will involve the demolition of nearly 700 houses, and it is estimated that the cost will be from two to three million pounds, while 4 or 5 years will be needed for its execution.

Fig. 1.

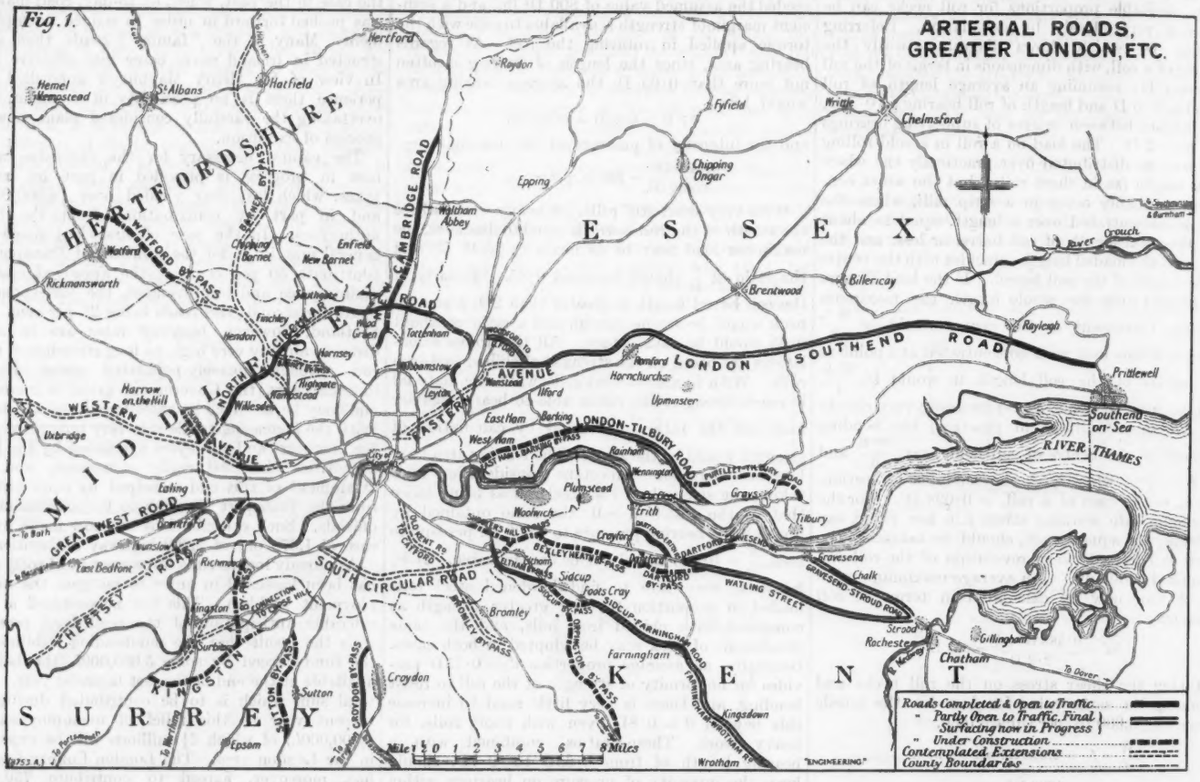
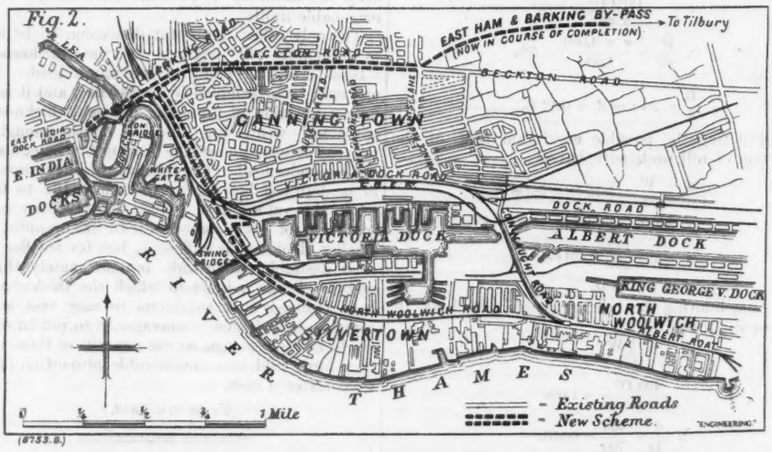


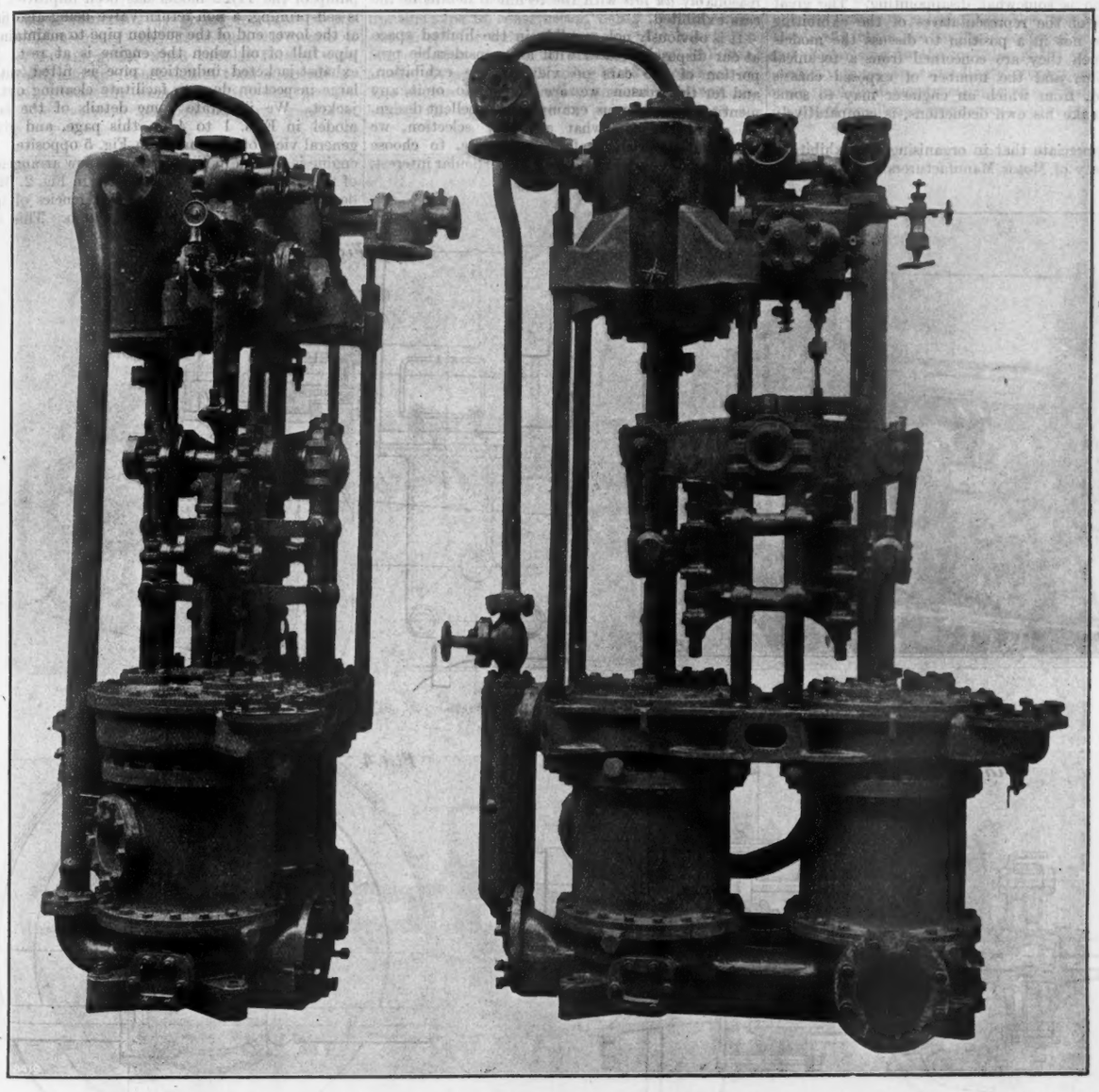
Fig. 2.



French Flotilla Leaders.—Two more of the very powerful new class of French flotilla leaders have been launched recently, the Leopard at the Chantiers de la Loire, and the Chacal at the Chantiers de Penhoët de Saint Nazare. The characteristics of these ships are: Displacement, 2,362 tons; i.h.p., 50,000; speed, 35·5 knots; endurance 2,600 miles at 18 knots; oil capacity, 540 tons; length, 400 ft.; beam, 36 ft.; draught, 11 ft. 6 in.; armament, six 5·1 in., and two 3·9 in., anti-aircraft guns; six 21·7 in., tubes in two groups of triple mountings. Their boilers are described as being small tubed, of the Temple type.

CONTRAFLO RECIPROCATING AIR PUMPS; EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. VICKERS LIMITED, ENGINEERS, BARROW-IN-FURNESS.



VICKERS' CONTRAFLO RECIPROCATING AIR PUMPS.

For the attainment of economy in steam plant it is essential that a high vacuum be maintained in the condenser. It is therefore imperative that the associated auxiliaries, such as air pumps, should be suitable to maintain the required conditions. The difficulties that early confronted the designers have been overcome, and air pumps that work under the new conditions with efficiency and economy are now available. In the accompanying illustration, two views are shown of reciprocating air pumps of the Contraflo kinetic type which were constructed by Messrs. Vickers, Limited, at their Barrow-in-Furness works and which are exhibited by the company at the British Empire Exhibition. These pumps were specially designed for marine use, but can, of course, be applied to land installations where the conditions are suitable.

This complete equipment consists essentially of three components, a steam jet ejector, a receiver, and a double air pump. The condensate is drawn from the foot of the condenser by the water barrel of the air pump, while the aerated vapour is withdrawn by the steam ejector and discharged with its own steam into a receiver, mounted beside the steam cylinder of the air pump. Here the incoming air and steam come into contact with a small portion of the condensate discharged from the water barrel of the pump. Actually the receiver is divided into two chambers, in one of which the discharge from the ejector is received, while the other acts as a devaporising compartment. The air barrel of the pump deals with the condensate and aerated vapour from the receiver. From the bottom of the receiver the condensate is conducted by a pipe to a valve chest, containing non-return valves, which are below the head valves of the pump but above the bucket, when in the top position of its stroke. The condensate from the receiver, therefore, enters the air barrel of the pump above the bucket, while the aerated vapour is drawn from the top of the receiver into the foot of the air barrel. To seal the foot valves and further to reduce the temperature of the aerated vapour from the receiver, a connection is made to the pipe conveying injection water to the receiver, so that some small amount of water is passed to the air barrel of the pump. By this arrangement the hot water from the receiver is kept away from the aerated vapour, until the latter has passed through the foot valves into the air barrel of the pump. Both are discharged together through the head valves into the common discharge system for both barrels. Whatever water is required for injection into the receiver, or for sealing the foot valves of the air barrel, is obtained from a deep well or pocket on the discharge side of the water barrel, and is shown on the left-hand side of the second view. The heat available in the steam used in the system, together with the heat of the aerated vapour, is conserved in the feed water, so that high efficiency is maintained throughout the working.

When the air pumps of an installation are of the ordinary design and are directly connected to the condenser, the effect of pneumatic resistance in the pipes is encountered, and it varies with the length and diameter of the pipe. As a consequence of this, a reduced pressure must be created in the air barrel to compensate for the further fall in pressure between the condenser and the air pump barrel. This drop in pressure is the cause of additional work in the air pump. Unless cooling is resorted to, the density of the aerated vapour becomes lower than that prevailing in the condenser, and consequently the pump capacity has to be increased. Should cooling be adopted, the trouble is not entirely removed, as the resistance to the passage of air, due to the presence of water in the pipes and valve chambers, is still present. In the kinetic type of air pump these disadvantages are non-existent, for the ejector can be mounted directly on the condenser and there is no water present, with the result that the pressure drop can be kept down to the minimum required to maintain the flow to the ejector. A reserve of air withdrawing capacity is obtained with the kinetic reciprocating pump system, which permits the running of the pumps at low speed, ensuring good steam consumption and little wear and tear. The illustration above shows a pair of air pumps built for a marine installation and such as were fitted in Nippon Yusen Kaisha ships.

THE MOTOR EXHIBITION AT OLYMPIA.

(*Continued from page* 554.)

From a purely engineering point of view, the exhibition is somewhat disappointing. The great majority of the representatives of the exhibiting firms are not in a position to discuss the models with which they are concerned from a technical standpoint, and the number of exposed chassis exhibited, from which an engineer may to some extent make his own deductions, is comparatively limited.

We appreciate that in organising the exhibition, the Society of Motor Manufacturers and Traders is mainly concerned with affording an opportunity for potential customers to view the various models under comfortable conditions, and to select the make and model most suited to their needs without a fatiguing peregrination to the various London show rooms. On the other hand, the exhibition affords a convenient opportunity for engineers who are not primarily concerned with automobile work to gauge the progress made in design during the past year. To such the difficulty of examining the various chassis and discussing technical details with the different manufacturers is somewhat trying. Even among the non-technical public, the knowledge of various details of automobile design is surprisingly great, and the superficial nature of the information possessed is apt to lead to prejudicial selections in the absence of a certain amount of technical explanation. It is true that failures to effect sales through such prejudices is likely to be impartially distributed, but we believe that it would be to the advantage of the various manufacturers to have at least one representative on each stand reasonably *au fait* with the technical details of the cars exhibited.

It is obviously not possible in the limited space at our disposal to deal with any considerable proportion of the cars on view in the exhibition, and for this reason we are obliged to omit any mention of numerous examples of excellent design. In making a somewhat arbitrary selection, we have endeavoured, as far as possible, to choose models which embody features of particular interest, either in the engine or in some other part of the chassis.

Before dealing with any new models, it will not be out of place to refer to one or two of the alterations in those with which we dealt last year.

We dealt fully with the products of the firm of Messrs. Wolseley Motors Limited, on that occasion, but now note that they have, wisely in our opinion, reduced the number of types they manufacture, and have also adopted the new two-figure nomenclature which is becoming standardised, the first figure representing the Treasury rating and the second the actual bench horse-power of the engine. The models exhibited at Olympia are thus referred to as the 11/22, 16/35, and 24/55. The 11/22 model, which is a most excellent car, is similar in its main essentials to the 10 h.p. model which we described last year, a number of minor improvements being incorporated. Magneto ignition is fitted to all models, the magneto having a positive drive by spiral bevel gears, and being arranged in a position which renders the contact breaker very accessible. The oil pump of the 11/22 model has been improved, and is self-priming, a non-return valve being also fitted at the lower end of the suction pipe to maintain the pipe full of oil when the engine is at rest. The exhaust-jacketed induction pipe is fitted with a large inspection door to facilitate cleaning out the jacket. We illustrate some details of the latest model in Figs. 1 to 4 on this page, and give a general view of the chassis in Fig. 5 opposite. The engine is shown in Fig. 1, and the new arrangement of the magneto and oil-pump drive in Fig. 2. When dealing with this car last year, exigencies of space prevented our illustrating the clutch. This is of somewhat unusual construction for a light car, being of the multi-plate type, and we now illustrate it in Figs. 3 and 4.

The 10/20 h.p. Galloway car has had a very favourable reception, and a number of minor improvements have been incorporated in the new model which should render it still more attractive. An impeller has been introduced to assist the water circulation, the rear of the engine has been dropped to give a more direct transmission alignment, and a banjo axle has been fitted. The worm and worm wheel in the steering column have been increased in size and the gear ratios have been altered. These are now as follows: 17·18, 11·53, 7·89 and 4·54 to 1. The accelerator pedal is now placed in the centre, instead of on the right-hand side of the brake pedal, and the ignition and hand throttle levers have been placed in a more convenient position above the

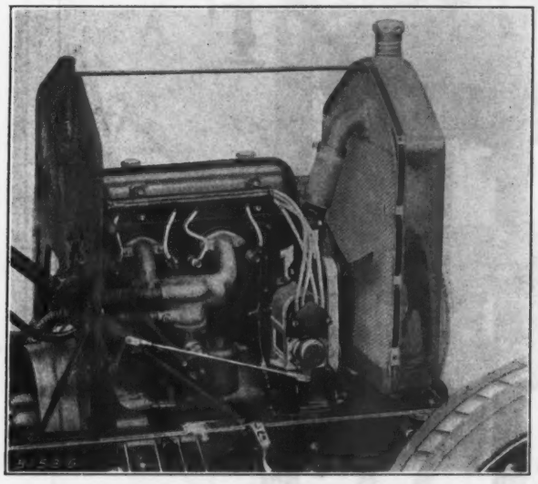
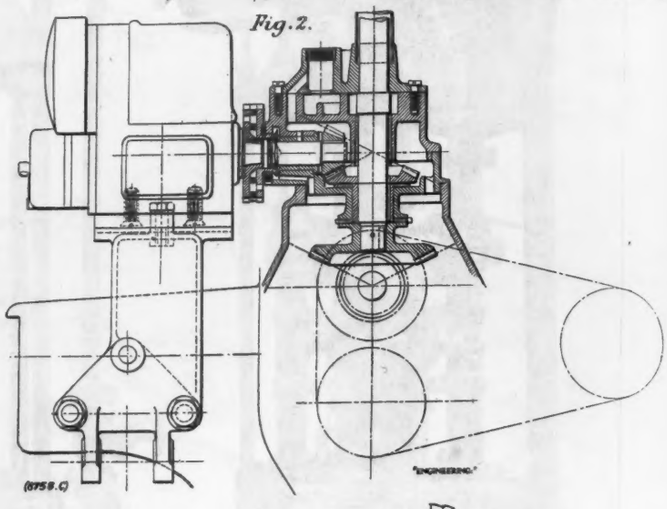
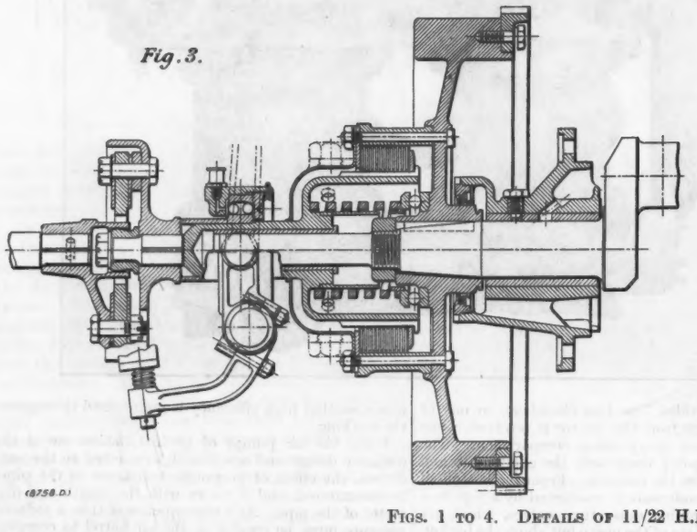
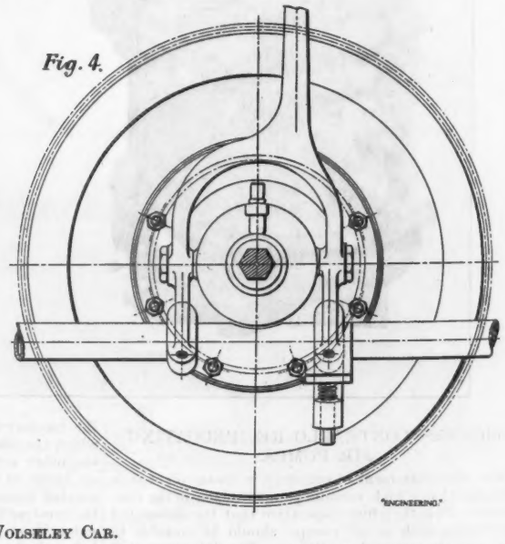


Fig 1.







Figs. 1 to 4. Details of 11/22 H.P. Wolseley Car.

steering wheel instead of below, as in previous models. Balloon tyres have been standardised on all models.

Many troubles arose in the earlier cars, due to frame distortion, and although this still occurs to a much greater extent than is generally realised, it has been minimised by giving increased depth to the side member. The latter took the form of a channel section girder when tubular frames were abandoned, and the construction then adopted has remained practically unmodified till the present time. The various components are generally mounted with a view to avoiding trouble, should frame distortion actually take place, although in many cars at present on the market, such distortion frequently affects the body causing separation of the panels, defective fitting of the doors and other evils. It is surprising that in a structure where weight is of primary importance very few attempts should have been made to utilise a trussed girder, instead of merely increasing the depth of the side member until distortion is eliminated. King and queen post trusses have been introduced from time to time, but the practice of joining the upper and lower flanges of the side frame with light lattice or similar construction has apparently never received serious consideration, although it would be possible to make a very strong and light frame by this method. An equivalent practice is adopted by Messrs. Lancia in their Lambda-Lancia model, which is to be seen on the stand of the concessionnaires, the Curtis Automobile Company, Limited. In this case the side frame forms an open girder, but takes the shape of a single pressing instead of being built up, this type of construction being probably more convenient for automobile work. The car has a four-cylinder engine, 75 mm. bore by 120 mm. stroke, giving an R.A.C. rating of 13·9 horse-power. The engine is of somewhat unusual construction, having the cylinders set in pairs, inclined at an angle of 14 deg. and slightly staggered. It is thus a V-type engine, with a very small angle between the cylinders. The overhead valves are operated by an overhead camshaft, driven by a vertical shaft with helical skew gearing. The lubrication is pressure fed throughout. Aluminium alloy pistons with tubular connecting rods are used. A three-speed gear box with central control is fitted with four-wheel braking, a hand brake on the rear wheels being fitted in addition in the usual way. The suspension is another unusual feature, being by coil springs and oil compressors in front and normal semi-elliptic springs at the back. The rear axle has spiral bevel final transmission, and is of normal construction; the clutch is of the multi-plate type, and the gear box is mounted separately from the engine. The gear ratios are 4·1, 7·25, and 11·7 to 1. Altogether the car forms an extremely interesting and unconventional assembly. We illustrate the chassis in Fig. 6, from which it will be seen that the side members of the frame are carried up to from the skeleton of the body. The side members are joined up by the radiator frame, dashboard frame, the front and rear seat foundation, and the housing for the propeller shaft. The whole assembly gives an exceedingly strong, but at the same time light construction, and results in a very low car of excellent appearance.

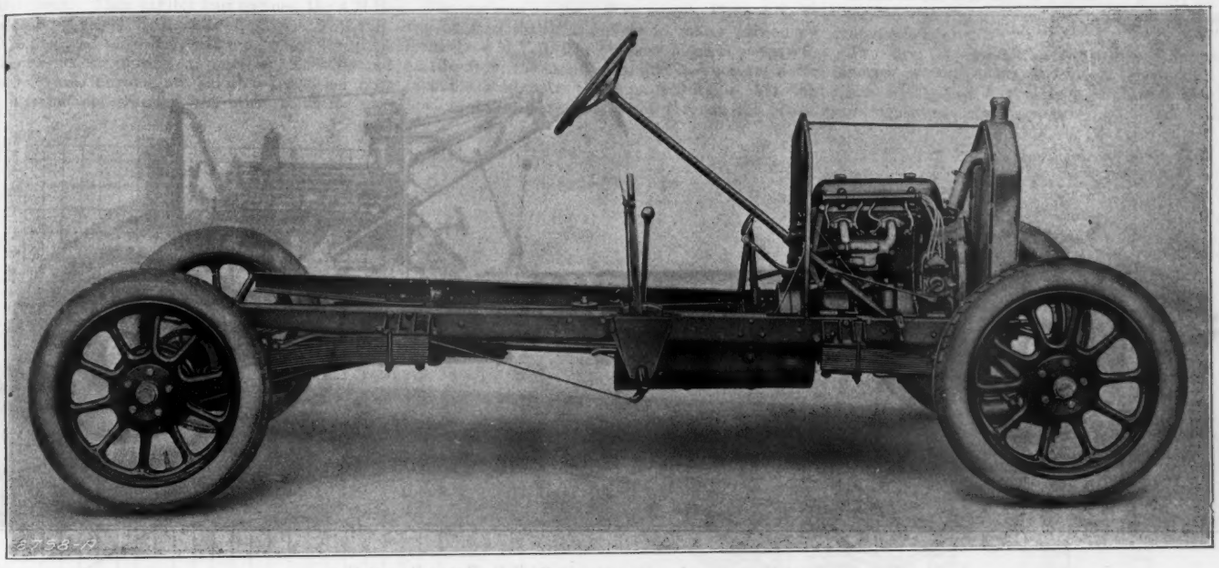


FIG. 5. CHASSIS OF 11/22 H.P. WOLSELEY CAR.

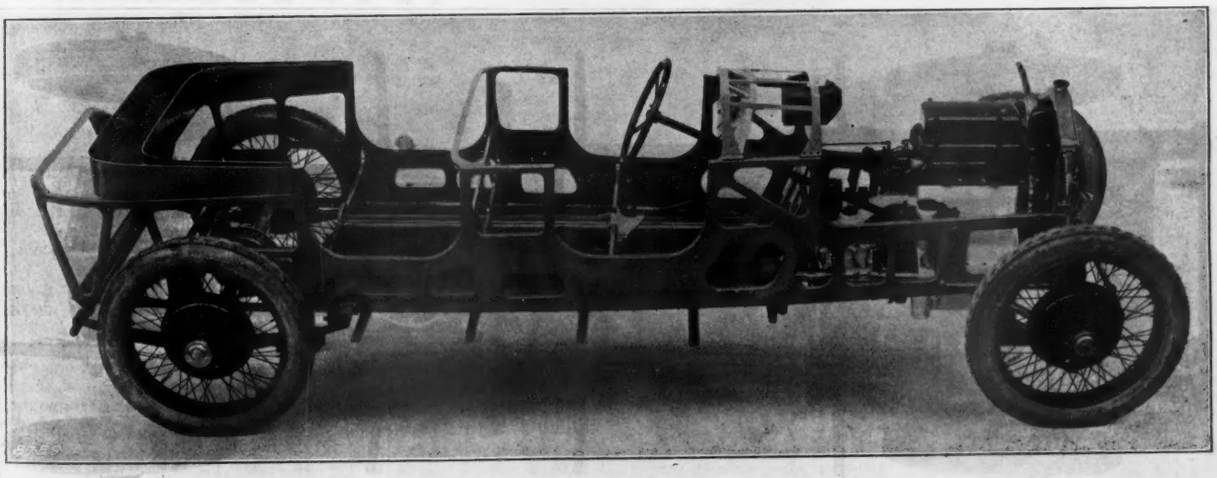


FIG. 6. CHASSIS OF THE LAMBDA-LANCIA CAR.

Messrs. Rolls-Royce, Limited, are exhibiting examples of their 40-h.p. and 20-h.p. models. The former is so well known that a detailed description is hardly necessary, the only change of any importance in this model being that front-wheel brakes are now fitted as standard. Amongst the detail changes may be mentioned the substitution of Autovac for the previous pressure-feed fuel supply. The dynamo is now driven from the engine, instead of from the clutch shaft, and the speedometer is now driven positively from the gear-box. The front wheel brakes are of the mechanical relay type, to assist the foot pressure. The foot pressure is used directly for the rear wheels, but at an intermediate point it causes the mechanical control to come into operation so as to apply the brakes to both front and back wheels. An equaliser is introduced which

ensures that a greater proportion of the braking power is applied to the rear as compared with the front wheels. This makes it impossible for the latter to be locked. A feature of the system is that the braking is equally powerful in whichever direction the car is moving. The usual hand brake operating on the rear wheels is fitted, and is entirely separate from the four-wheel system, so that there are six brakes in all.

The 20-h.p. model manufactured by this firm is of recent introduction, and is shown at Olympia

Fig. 12. In the 40-h.p. model the starting carburettor is on the induction pipe, but in this model it is incorporated with the main carburettor.

Ignition is normally by coil, but in addition a magneto is now fitted as standard. The latter is normally out of action, but may be coupled up by merely releasing a locking pawl on the magneto driving shaft. As there is only one set of plugs, the same distributor serves both for the coil and magneto ignition, and it is therefore necessary to change over the high-tension wire leading to the

standard nor optional. This feature does not appeal to us in a design which is otherwise excellent. A somewhat special feature on the car is the provision of a radiator shutter which can be operated by hand from the driver's seat, a thermometer being provided to indicate the correct setting. Bigger lamp brackets are optional.

We have previously had occasion to refer to the importance of standardisation if the British manufacturer is to compete on terms approaching equality with American competition. Of the large

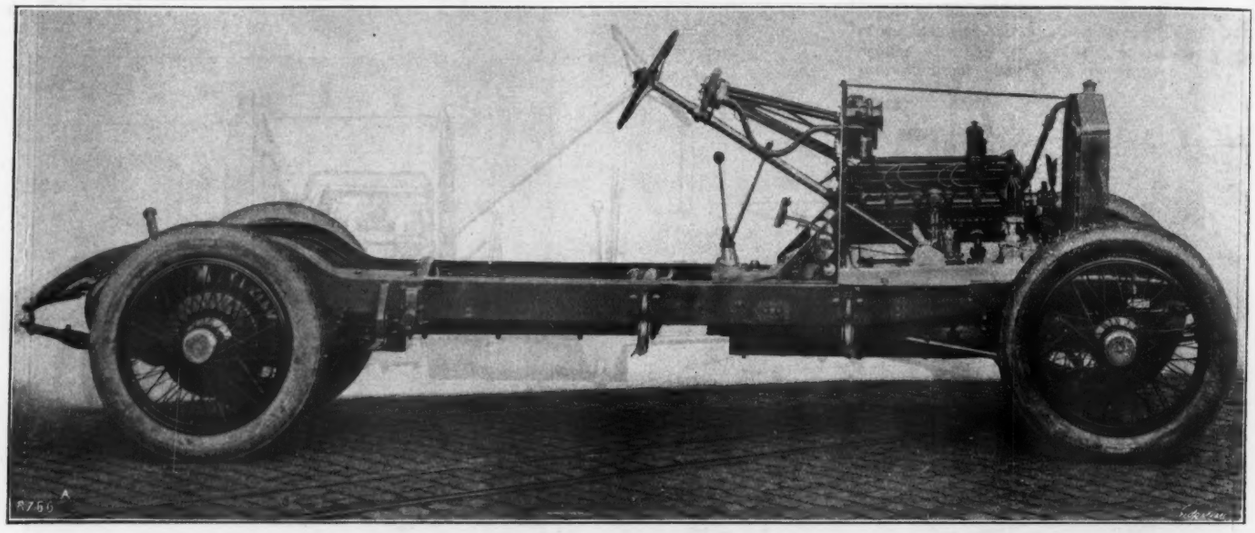


Fig. 7. Side Elevation of Chassis of 20-H.P. Rolls-Royce Car.

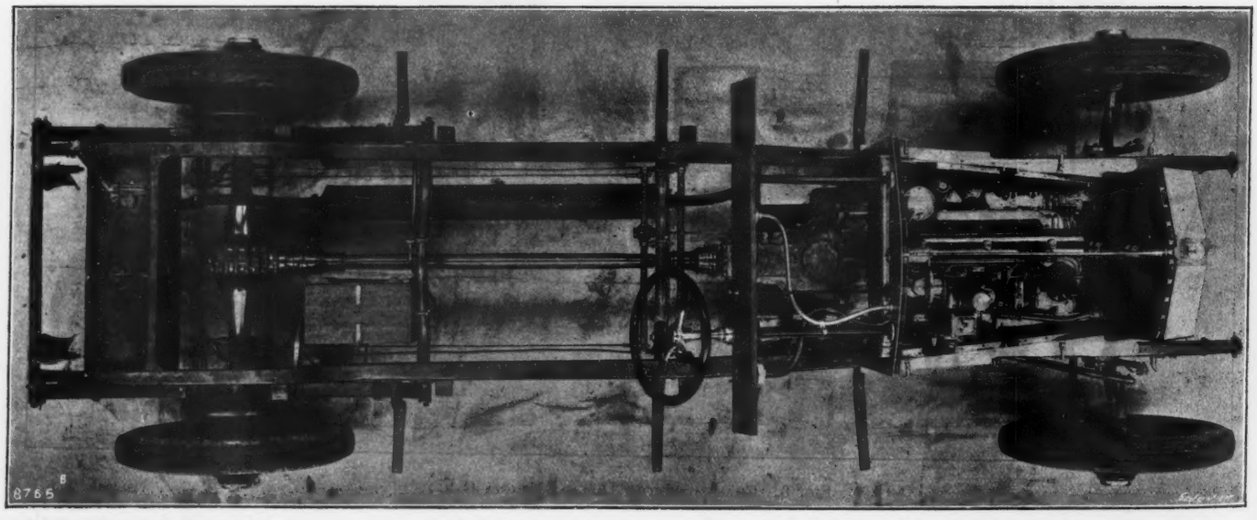


Fig. 8. Plan of Chassis of 20-H.P. Rolls-Royce Car.

for the first time. The engine is a six-cylinder 3-in. bore by 4½-in. stroke, giving a Treasury rating of 21·6 h.p. We illustrate this car in Figs. 7 and 8 on this page, and 9 to 12 on Plate LVIII. Overhead valves are fitted in combination with a detachable head. A Rolls-Royce carburettor is bolted to the cylinder block on the off side of the engine, from which the gases pass through the cylinder block to the inlet manifold on the near side of the engine. The exhaust manifold is also on the near side of the engine, and the exhaust gases pass through a muff surrounding the centre of the induction manifold before going to the silencer. This arrangement is clearly shown in

distributor when running the engine on the magneto. The magneto is arranged in line with and behind the dynamo on the near side. When running on the coil 35 deg. more advance may be obtained than when the magneto is in action.

The engine is mounted on three-point suspension, a single-plate clutch and three-speed gear-box with central change, making up one unit with the engine. Spiral bevel final drive is used on the rear axle, the general arrangement of the transmission being clearly shown in Fig. 10. The springing, both front and rear, is semi-elliptic, and braking is on the rear wheels only. The car is almost unique in its class in that front-wheel brakes are neither

number of manufacturers showing cars at the exhibition, a considerable proportion market two or more different forms of each of the units necessary to make up the complete vehicle. There are thus a very large number of different engines, for example, to be seen at the exhibition, many of them being of almost identical power and size. The British manufacturer is undoubtedly unrivalled for the perfection of his products, but however perfect these may be, they must of necessity be excessively high in price so long as they are manufactured in the small numbers determined by the present policy of isolation adopted by the great majority of the manufacturers, and a very strong case can be

made out for the adoption of standard engines on many models of different makes. Such a policy is already recognised as correct for a number of components, outstanding examples being the magneto and carburettor.

Messrs. Dorman and Co., Limited, of Stafford have specialised in a range of engines which cover the requirements of the great majority of manufacturers, and have earned a high reputation for sound design in combination with the use of excellent materials and a high degree of accuracy. The finish of the products is exceptionally good throughout. They exhibit four engines, the 4 M.R. 16/40 h.p., the 4 R.O. 12/40 h.p., the 4 M.V.B. 10/25 h.p., and the 4 P.A. 9/18 h.p., which are specially designed for touring car practice. The first and last of these engines are suitable for either unit or non-unit construction, the other being for unit construction only. The 4 R.O. is an overhead valve model, the other three being of the side-by-side valve type. All four are four-cylinder engines.

Fig 19

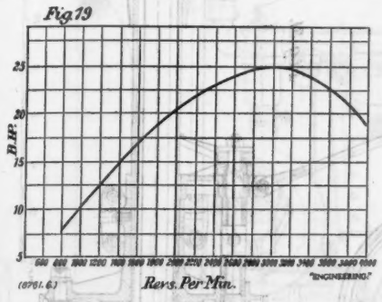
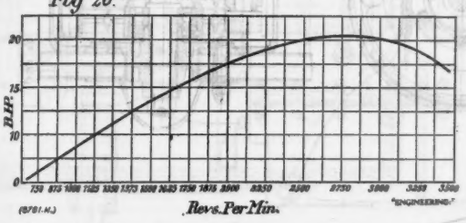


Fig 20.



The firm are also exhibiting the Dorman four-speed gearbox with either side or central control, and a three-speed gearbox with central control for unit construction.

We illustrate the 4 M.V.B. and the 4 P.A. engines, in Plates LIX and LX, and the four-speed gearbox in Fig. 21 on this page. Power-speed curves on full throttle are shown for both engines in Figs. 18 and 19.

Dealing with the 4 M.V.B. model first, it will be seen from Figs. 13 to 15 on Plate LIX that the cylinder block is cast in one piece with the upper half of the crank-case, the starter being on the off side and the dynamo on the near side. The starter is housed in an extension of the rear supporting bracket. The carburettor and magneto are both on the off side of the engine, the magneto lying at an angle in an extremely accessible position high up on the engine, and driven by skew gearing. A fine adjustment is provided by means of a collar locking a spliced shaft. The drawing shows the dynamo as being belt driven, but in the latest model a chain drive is adopted. The whole appearance of the engine is very neat. Referring to the two sectional views, it will be seen that the camshaft is gear-driven from the crankshaft, the tappets operating directly on the cams, the arrangement of the valves following normal practice. The cylinders have a detachable head, and combustion heads entirely free from pockets results from this practice, the sparking plug being almost central in each chamber. The carburettor, a Zenith H.A., is bolted directly on to the cylinder block, the induction passage passing right through the cylinder block between the two central cylinders, and afterwards running parallel to and underneath the exhaust manifold making contact at three places; this gives three hot spots. The exhaust manifold is of rectangular section and ribbed in the usual way for cooling. The exhaust and induction manifolds thus form one casting, which can be readily removed for cleaning.

The oil pump is driven by spiral gear from the camshaft, and is of the gear type, situated below the permanent oil level in the base chamber. Both the crank and camshafts are of the three-bearing type with pressure feed from the oil pump. The cylinder lubrication is by trough in the usual way. The engine is 69 mm. by 100 mm. and, as will be seen from the power curve given in Fig. 19, develops 25 h.p. at 3,000 r.p.m.

Turning now to the 4 P.A. model, Plate LX, it will be seen that this differs in many particulars from the 4 M.V.B. The cylinder block is a separate casting from the crank-case, and has not got a detachable head. An excellent feature is that the holding-down bolts pass right through the block, the nuts being in an exceptionally accessible position on top of the cylinders.

Fig. 21.

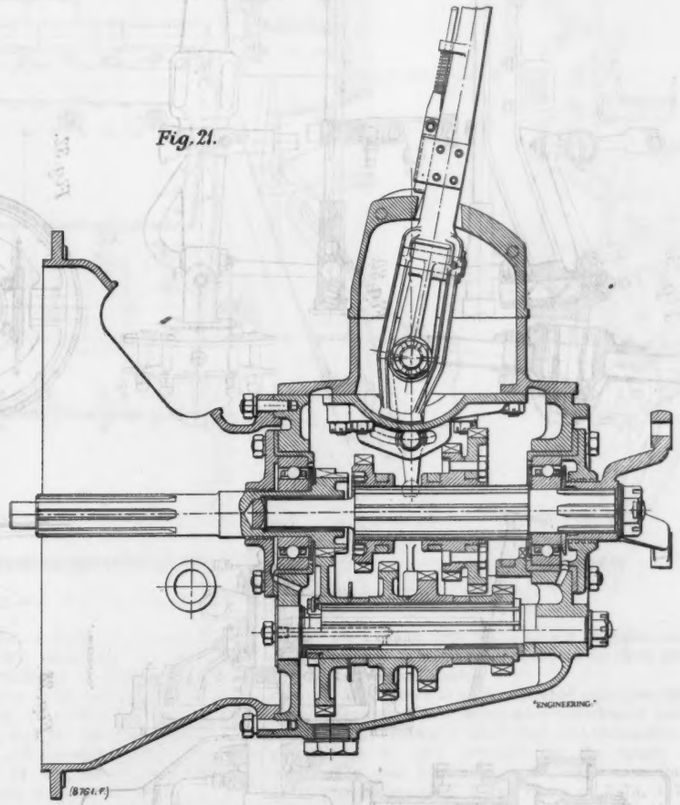


FIG. 21. FOUR-SPEED GEARBOX; MESSRS. DORMAN AND CO., LIMITED.

In the earlier models of the engine rocking levers were introduced between the tappets and valves, but in the later model the tail of the valve terminates in a circular foot which bears directly on the cams. On this account the valve guides are made of unusual length and diameter. A somewhat novel feature of this engine is that on opening the tappet inspection cover the whole interior of the crank-case is exposed, and the valves cannot therefore be viewed while the engine is running. The starter is arranged in the same position as in the 4 M.V.B., the dynamo being positively driven by means of a roller chain in the timing wheel casing. The carburettor is mounted on the near side below the exhaust manifold, the induction system in this case being totally contained within the cylinder block.

As a detachable head is not fitted the usual valve caps are provided for the removal and inspection of the valves, and on this account the combustion chamber is not quite of such a clean shape as in the 4 M.V.B. model. For the same reason it has been necessary to mount the sparking plugs in the valve caps in the usual way. The oil pump in this engine is of the plunger type, driven from the camshaft. Both the camshaft and crankshaft are of the two-bearing type. The timing wheels are skew-cut gears and the fan is driven by belt from a pulley on the crankshaft. Both engines have die-cast aluminium alloy pistons. The engine is 66 mm. by 100 mm., and it will be seen from the power curve, Fig. 20, that it develops 20·4 h.p. at 2,760 r.p.m. This engine has put up some most excellent performances and is a very interesting example of a somewhat unconventional design. If we may venture on the criticism of a detail it is that the oil filler, though in an excellent position, is totally inadequate in size.

The firm of Gwynnes Engineering Company, Limited, are exhibiting two interesting models, of 8 h.p. and 14 h.p. respectively, in their temporary showrooms in Hammersmith-road. The 8-h.p. model has put up some excellent performances in the past year, including the winning of the *Daily Chronicle* cup in the R.A.C. 1,000 miles reliability trials. We illustrate this car in Plate LXI, Figs. 22 to 24, and by Figs. 25 to 33 on page 578. The engine is 55 mm. bore by 100 mm. stroke, giving an R.A.C. rating of 7·6 h.p. As will be seen from the section, Fig. 25, the engine is a four-cylinder, overhead valve model, with the camshaft enclosed in the crank-case, the valves being operated by tappet rods in the usual way for this form of construction. The compression ratio is 4·7 : 1, and the crank-connecting rod ratio 3·76 : 1. Aluminium alloy pistons are used with carbon steel rods. The gudgeon pin is locked in the connecting rod, the pistons being bushed to form the bearing. The valves are 3 per cent. nickel steel. The engine develops 20 h.p. at 3,000 revolutions per minute, a somewhat exceptional performance for such a small capacity. Ignition is by C.A.V. magneto, mounted on the near side of the engine, and an S.U. carburettor is fitted on the off side, the induction pipe being water jacketed. Helical cut gears are used for the timing train. Both the crankshaft and camshaft are mounted in three bearings. The engine is fitted with a detachable head. The thermo-syphon cooling

DETAILS OF 8/23-H.P. FOUR-CYLINDER MOTOR CAR.

CONSTRUCTED BY GWYNNES ENGINEERING COMPANY, LIMITED, CHISWICK, LONDON.

Fig. 25.

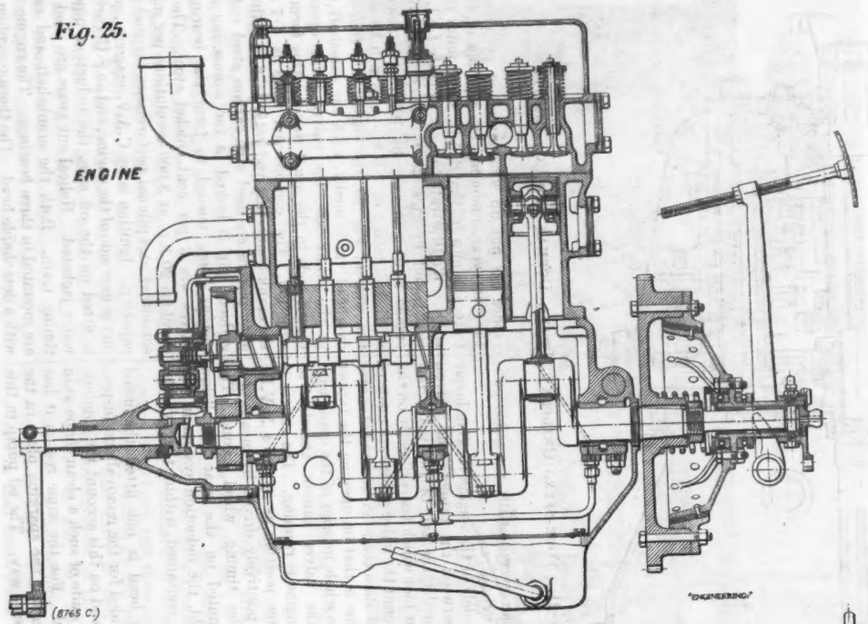


Fig. 26.

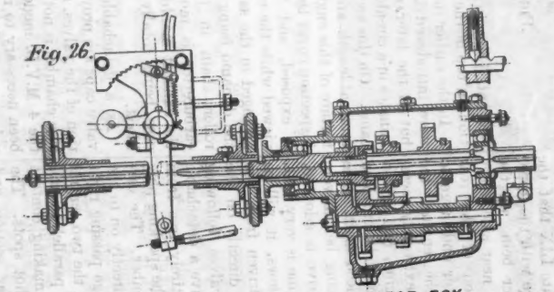


Fig. 27.

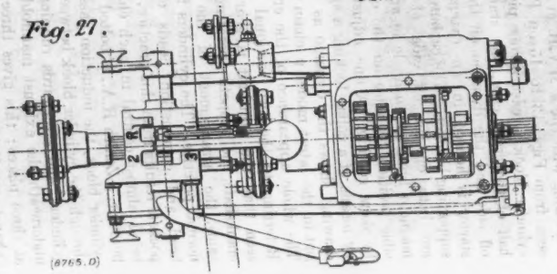


Fig. 28.

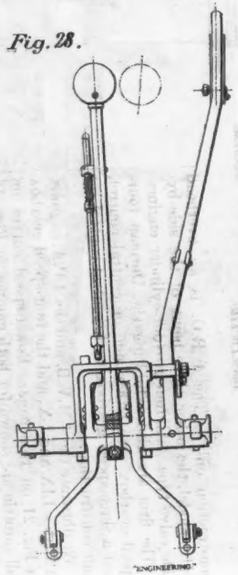


Fig. 29.

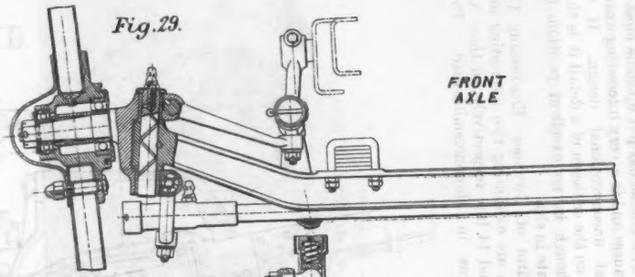


Fig. 30.

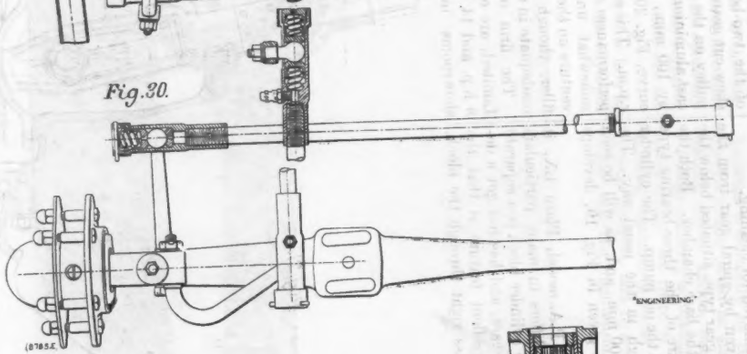


Fig. 32.

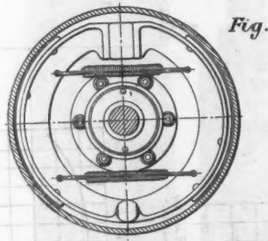


Fig. 33.

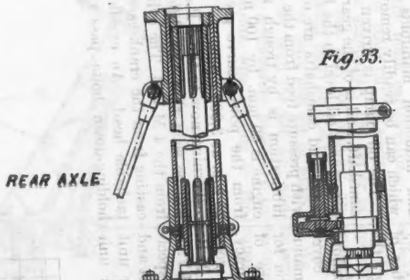
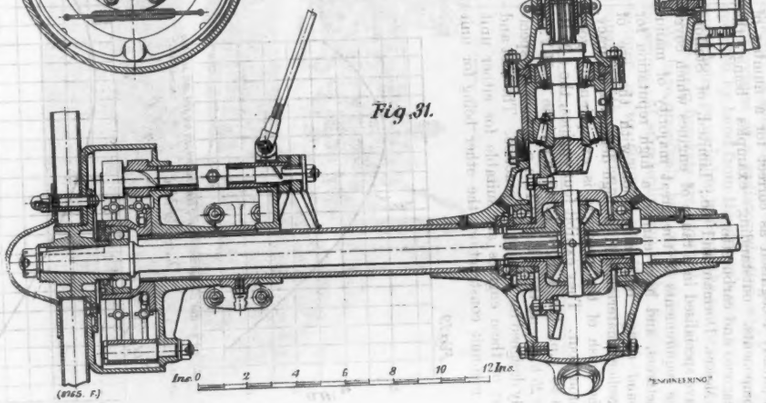


Fig. 31.



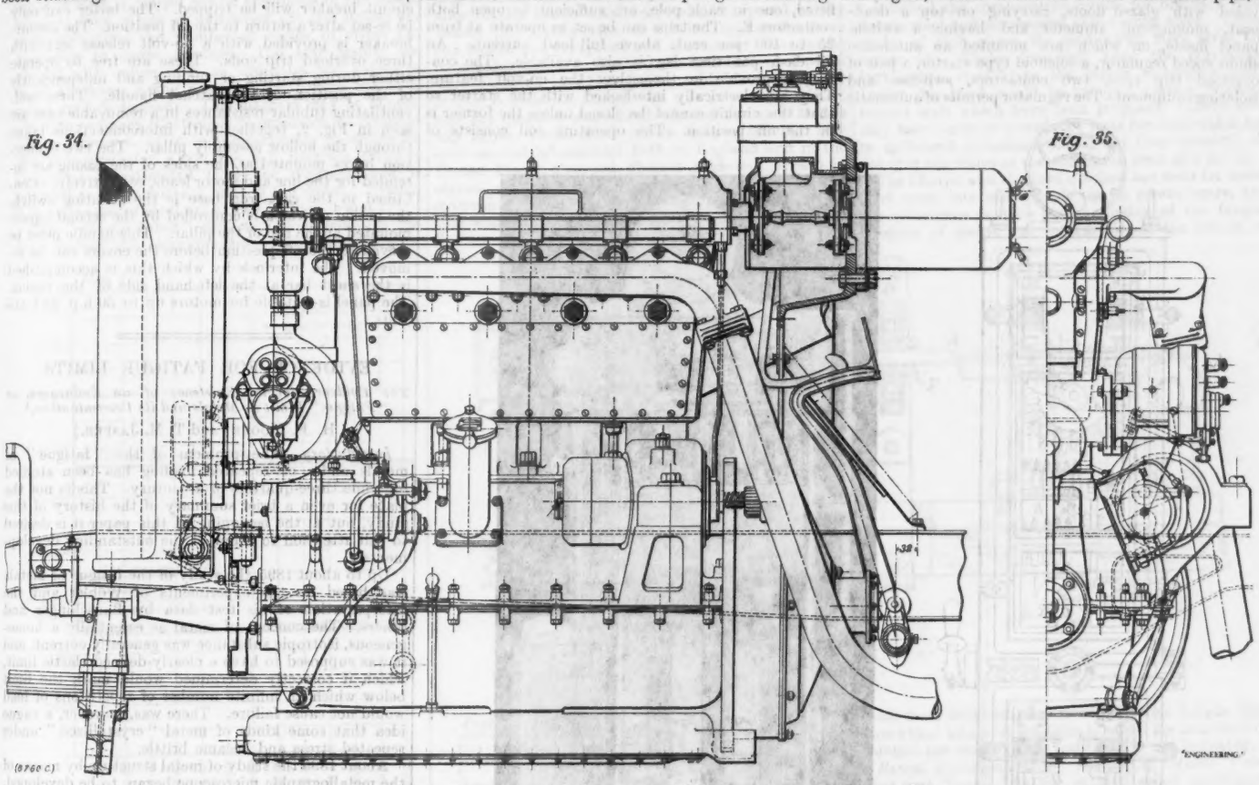
system is well carried out, no fan being necessary. The outlet pipe at the top of the cylinders is of quite exceptional size, and it is probable that this has an appreciable effect in preventing local overheating. Lubrication is by pressure feed throughout, a gear pump being driven from the end of the crankshaft. A priming chamber is arranged to ensure that the pump cannot run dry after the engine has been standing.

adjustment. Provision is made in the rear axle for the speedometer drive. Side-by-side rear-wheel brakes are fitted, operated by steel cables. A screwed adjusting rod is provided at one end of each cable, this being all that is necessary as the cables for both sets of brakes are continuous, starting at one wheel, passing forward through the compensator, and then returning to the other wheel. The cables make a somewhat sharp angle in entering

controlled by an automatic thermostat. The ignition is by two M.L. magnetos, with synchronised variable advance. Lubrication is by pressure to the main bearings and big ends with splash to the pistons and small ends. The camshaft bearings, cams and valve rockers are lubricated by pressure-fed supply through the hollow camshaft. Two S.V. carburettors are fitted on the off side of the engine, bolted direct on to the induction pipe,

Fig. 34.

Fig. 35.



FIGS. 34 AND 35. ENGINE FOR THE 3-LITRE SPORTING-MODEL BENTLEY CAR.

The clutch is of the leather-to-metal, reversed cone type. A three-speed gear-box is fitted, giving ratios of 14·25, 9·15, and 4·83 to 1, the reverse ratio being the same as the first. A somewhat special feature of this car is the complete provision for relieving the springs of all torque stresses. The gear-box is mounted in an approximately central position, but really forms part of the rear axle unit, as it is rigidly connected to the torque tube. The whole of the rear axle unit formed in this way is anchored on a ball joint formed on a stiff arm which projects from the gear-box at the forward end, and on the off side of the box. The position of the control is optional, and when it is fitted on the right-hand side the control extension casing is mounted on a ball joint on the gear-box and is anchored by shackles to the side member of the frame, so that all stresses in the casing due to torque reactions are avoided. The gears are made of air-hardening, nickel-chrome steel.

As will be seen from the illustration of the back axle, Figs. 31 and 33, this is of the semi-floating type, and is underslung. The final transmission is by spiral bevel. An interesting feature of this axle is that it is built up entirely of steel stampings, with the exception of the outer periphery of the central casing, which is a steel casting. The differential is of the two-pinion type. It will be noticed from the drawing that the bevel pinion shaft is mounted in a separate sliding sleeve, which may be moved in and out by means of an internally-screwed distance piece, which is normally locked in position by the casing assembly bolts. The depth to which the pinion meshes with the crown wheel can, therefore, be adjusted by merely removing these bolts and turning round the collar of the distance piece by means of a special spanner. A sight hole is provided in the side of the casing to facilitate the

the compensator tube, and it would seem likely that they may wear out comparatively rapidly owing to a tendency to chafe through at this point.

The radiator is of the honeycomb type, with a separate shell; petrol feed is by gravity from a dashboard tank, and the steering gear is of the usual worm type, with a complete wheel. The total weight of the car is 12 cwt., the wheel base being 7 ft. 3 in. and the track 3 ft. 6 in.

A very interesting car to be seen at Olympia is the 3-Litre Bentley. Although this car is of very recent introduction, being first produced in 1921, it has rapidly achieved recognition as a car of outstanding merit. The firm of Messrs. Bentley Motors, Limited, of Cricklewood, London, N.W.2, market a standard and a speed model chassis, which differ in a number of details. The chief differences are that the standard model has a longer wheelbase, a lower compression ratio, and lower gear ratios. Both models are distinguished by unusual speed capabilities, combined with smoothness in running and exceptional silence. We illustrate the sporting model chassis in plan and elevation in Figs. 36 to 38, on page 584, and the engine in Figs. 34 and 35 above. Dealing first with the engine, this is of the four-cylinder type, 80 mm. bore by 149 mm. stroke. The cubic capacity is thus 2,996 c.c. and the Treasury rating 15·9. There are two inlet and two exhaust valves in each cylinder, arranged in the head and operated by a totally enclosed overhead camshaft and rockers running in oil. Both crankshaft and camshaft are of the five-bearing type. The camshaft is driven by a totally enclosed vertical shaft through spiral bevels. The compression ratio is 5·3 : 1, and the crank-connecting rod ratio 295 : 149. Aluminium alloy pistons are used in conjunction with nickel chrome steel rods. The valves are of stainless steel. Cooling is by pump circulation

the exhaust pipe being on the opposite side of the engine. The oil pump is driven by skew gears from the vertical shaft.

The clutch is of the inverted cone type lined with Ferodo. The compensated withdrawal mechanism is automatically lubricated, and automatic lubrication is also provided for the spigot bearing. The gear box forms a separate unit, four gears being provided, giving ratios of 3·78, 4·76, 5·77 and 9·32 to 1. The gears are ground, thus giving very silent action. The rear axle is made of two pressings welded together, a large inspection door enabling the differential assembly to be withdrawn in one unit. The final transmission is by spiral bevel. No torque tube is provided; the forward universal is of the two-pin type with plain bearings, totally enclosed and running in grease, and the rear universal is of the sliding block type. The springing is semi-elliptic both front and rear.

(To be continued.)

THE BUFF BOOK OF MESSRS. SELLS, LIMITED.—The October issue of the "Buff Book," the Trade and Commercial Directory for London, is now ready, and by an arrangement with H.M. Postmaster-General a copy of this issue will be delivered to every subscriber to the London Telephone Exchange system. The publishers are Business Telephone Directories, Limited, 25, Lawrence Lane, London, E.C. 2.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—The Council of the Institution have made the following awards for papers read during the past session:—Crompton Medal: Awarded to Dr. Aitchison for his paper entitled "Light Alloys for Pistons and Connecting-rods." Utility Prize (given by Col. D. J. Smith for the paper of greatest utility to the automobile industry): Awarded to Dr. Aitchison for the above paper. Graduates' Prize: Awarded to Mr. R. N. Aveline, of the Coventry Branch, for his paper entitled "Carburation."

ELECTRIC MOTOR-CONTROL GEAR AT THE BRITISH EMPIRE EXHIBITION.

Included in the very complete collection of switchgear shown at the British Empire Exhibition by Brookhirst Switchgear Limited, of Chester, are the direct-current ironclad panel, illustrated in Fig. 1, and the oil-immersed, hand-operated, alternating current control gear of Fig. 2, herewith. The former apparatus comprises a substantial ironclad casing provided with glazed doors, carrying on top a dead-beat, moving-coil ammeter and having a switch-panel inside, on which are mounted an automatic shunt speed regulator, a solenoid type starter, a pair of overload trip coils, two contactors, switches and isolating equipment. The regulator permits of automatic

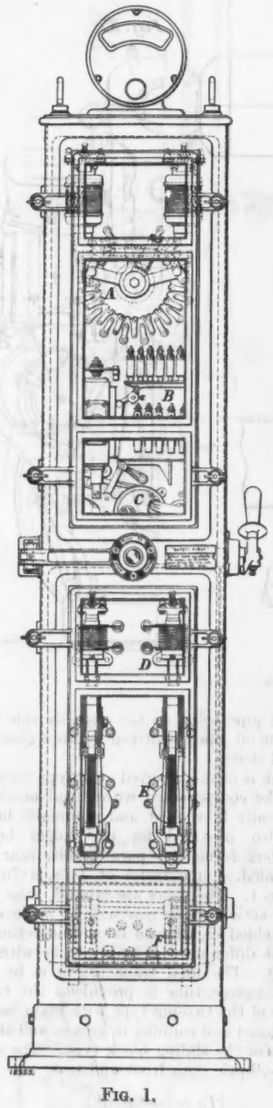


Fig. 1.

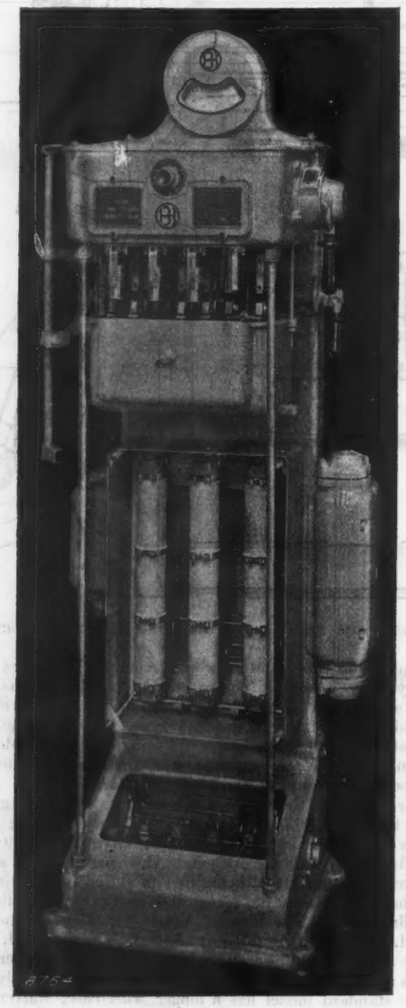


Fig. 2.

variation of the speed of the motor under control by push button. The shunt regulating contacts A are arranged radially. The moving laminated copper brush is actuated by a ratchet wheel driven by one or other of the two solenoids according as it is desired to accelerate or retard the speed of the machine. The solenoid type automatic starter and accelerator B possesses two interesting features in its movement and timing. Firstly, the fixed contacts are of carbon, mounted in stamped brass holders. Behind each carbon is a spring, which ensures the requisite pressure between fixed and moving contacts. The moving contact consists of a bar operated by a single solenoid in such a manner that each carbon is approached with a direct butt movement. The bar presses the carbon home into the holder and a subsequent slight sliding motion tends to clean the contact surfaces. The second feature is the use of an eddy current retarder C in connection with the timing. The solenoid plunger, acting through a rack and a train of gears, causes an aluminium disc to revolve between the poles of an electro-magnet excited by the main armature current. The eddy currents generated in the disc exercise a braking effect upon it, and, further, through the medium of the gearing, on the plunger. Since this effect varies in direct proportion to the starting current, the retarder permits of the desired quick starting with light loads and slow starting with heavy loads.

Either of the two independent overload trip coils D fitted, one in each pole, are sufficient to open both contactors E. The trips can be set to operate at from 25 to 100 per cent. above full-load current. An oil dash pot time lag is also available. The contactors provide in themselves the no-volt feature. They are electrically interlocked with the starter so that the circuit cannot be closed unless the former is in the off position. The operating coil consists of enamelled copper wire wound in layers, and impregnated. The terminals consist of built-in brass strips. By means of the double pole isolating switch current may be entirely cut off from all gear and interconnections within the pillar. The handle of the isolating switch is visible at the side of the panel in the figure, and is mechanically interlocked with the doors of the switchgear case so that they cannot be opened unless the isolating switch is off. The panel is well suited for controlling any motor-driven type of machine tool where automatic regulation to any speed together with frequent starting and stopping is necessary. In such a case, push buttons may be mounted on the bed of the machine, the panel being situated some distance away if desired.

In Fig. 2 an A.C. motor starting pillar, with isolator and cover interlock, is shown. The construction comprises a complete starting unit, circuit breaker, resistances, isolator, &c., encased in a hollow assembly frame, together with a cast-iron hooded ammeter mounted on top of the latter. The three-phase starting unit is oil immersed, and is of the multiple switch design, the several switches being controlled by a ratchet handle. By this latter means the circuit breaker is first closed, and then the starting switches in correct sequence. A feature of the design is that the arrangement of the gear requires the starting operation, once commenced—by means of the top handle at the right-hand side of the panel—to be completed, or the circuit breaker will be tripped. The latter can only be re-set after a return to the off position. The circuit-breaker is provided with a no-volt release and with three overload trip coils. These are free to operate either during starting or running and independently of the position of the ratchet handle. Three self-ventilating tubular resistances in a removable case are seen in Fig. 2, together with interconnections taken through the hollow assembly pillar. The two connection boxes mounted at the sides of the casing are intended for the line and motor leads, respectively. Contained in the cast iron base is the isolating switch, the action of which is controlled by the second handle mounted at the top of the pillar. This handle must be moved to the off position before the covers can be removed. The interlock by which this is accomplished is the short bar at the left-hand side of the casing. The panel is suitable for motors up to 50 h.p. and 415 volts.

EVIDENCE FOR FATIGUE LIMITS.

*The Evidence for the Existence of an Endurance, or "Fatigue" Limit in Metals and its Determination.**

H. F. Moore† and T. M. Jasper.‡

Introductory.—The problem of the "fatigue" of metals under oft-repeated loading has been studied for some three-quarters of a century. This is not the place for even a brief summary of the history of this study, but at the beginning of this paper it is desired to call attention to a few of the outstanding developments.

Up to about 1895, the study of the fatigue of metals was based on the experiments of Wöhler and the interpretation of his test data by Bauschinger and others. The concept of metal as essentially a homogeneous, isotropic substance was generally current, and it was supposed to have a clearly-defined elastic limit, which if correctly determined would mark the limit below which an infinite number of repetitions of load would not cause failure. There was, however, a vague idea that some kinds of metal "crystallized" under repeated stress and became brittle.

About 1895 the study of metal structure by means of the metallographic microscope began to be developed, and about the beginning of the twentieth century the well-known researches of Ewing, Rosenhain, and Humphrey and their discovery of "slip bands" threw light on the mechanism of fatigue fracture, and gradually led metallurgists, materials testing engineers and students of the mechanics of materials to recognize the basic difference between static failure of metal and the progressive failure which takes place under repeated stress.

In 1910 Professor Basquin of Northwestern University read a paper before the American Society for Testing Materials, entitled, "The Exponential Law of Repeated Stress." In this paper he examined the data of repeated-stress tests then available and concluded that it was not certain that there was any limiting stress below which fatigue failure would never take place, but that a *safer* view for the user of metal to take was that stress and "life" of metal were given by a relation of the form $S = B/N^m$ in which S is the fibre stress (in lb. per sq. in.), N is the number of cycles of stress to cause failure and B and m are experimentally-determined constants. Especially in the United States, his challenge to the current view has been productive of much discussion with a resulting broadening idea as to the nature of fatigue failure, and together with the growing use of alloy steels, heat-treated carbon steels, and high-speed machinery (especially the internal combustion engine and the steam turbine) has made clear the urgent need for further repeated-stress tests which should be carried to many more cycles of stress than were the tests of Wöhler and his successors.

The S–N Diagram and the Endurance Limit.—During the period of the study of the fatigue of metals the machine designer and the structural engineer have always asked the question: "For any given metal is there a limiting stress below which the metal will not fail no matter how often the load is repeated, and if so

* Read before the Engineering Section of the British Association at Toronto, on August 11, 1924.

† Research Professor of Engineering Materials, University of Illinois, In charge of Investigation of the Fatigue of Metals.

‡ Research Assistant Professor of Engineering Materials, University of Illinois, Engineer of Tests, Investigation of the Fatigue of Metals.

what is that stress for each of the common stress-carrying metals?" The only positive answer to this question is the answer of direct experiment, and it is evident that in the finite time available for any set of experiments the answer must always be a partial one. To the hoped-for limiting stress the name "endurance limit" or "fatigue limit" is commonly given.

The method of estimating the endurance limit of a metal from the data of repeated stress tests has been practically the same in all extended investigations. A series of tests is carried out on specimens of the metal, using various values of unit-stress (S) and noting for each unit-stress the number of cycles of stress (N) necessary to cause fracture. The test results are plotted with values of S as ordinates and values of N as abscissæ, giving what in the United States is called an S-N diagram. This diagram may be plotted either to ordinary (Cartesian) co-ordinates, to logarithmic co-ordinates, or to semi-logarithmic co-ordinates. The unit-stress for which the S-N diagram becomes horizontal is estimated from the diagram, and is reported as the endurance limit of the metal. Typical S-N diagrams for steel are shown in Figs. 1 and 2.

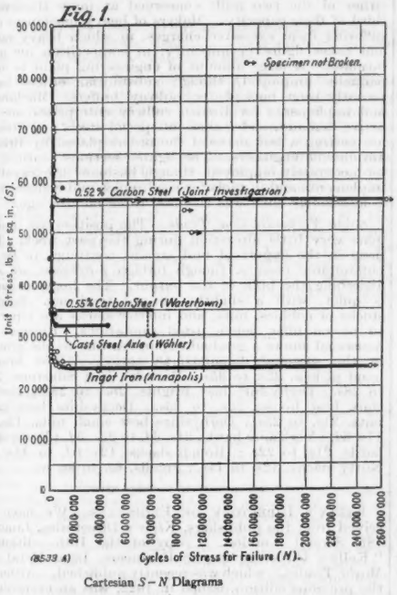
The "Elastic Limit" and its Limitations.—In the days before the development of the metallurgical microscope, when metal was thought of as homogeneous and isotropic, the elastic limit was conceived as having a definite value, and it was very natural that this elastic limit should be regarded as the endurance limit. Most discussions about the elastic limit have been confined to the discussion of methods for determining it, and there has been very little discussion of its significance—and of its limitations. In the light of present-day knowledge, the elastic limit seems unreliable as an index of fatigue strength for several reasons: (1) The value determined as the elastic limit of a metal depends on the delicacy of the measuring instruments used, and on the precision of plotting of the stress-strain diagram; (2) the value of elastic limit is affected by the initial quenching, rolling or forging strains in the metal, the amount of mechanical work which has been performed on the metal tending to adjust the initial strains; (3) the elastic limit changes value after a few cycles of stress are applied to a metal; and (4) in determining the elastic limit a minute defect in the metal has no appreciable effect on the value determined, whereas such a defect may have a very considerable effect on the value of the endurance limit.

The elastic limit of a metal depends on the average behaviour of a considerable mass of the metal; the endurance limit depends on the behaviour of microscopic portions of the metal.

The Mechanism of Fatigue Breakdown of Metal.—Before discussing two proposed "short-time" methods for determining the endurance limit, it seems desirable to give some attention to the phenomena of fatigue failure as shown by the metallographic microscope.

The discovery of "slip bands" has been noted above, and the regular sequence of events in the fatigue failures first studied under the microscope was: (1) Appearance of slip bands within crystals, (2) spread of slip bands, (3) development of cracks, apparently from slip bands, and (4) spread and junction of these cracks to complete failure. Later single-load failures of metal were observed in which failure took place along the crystal boundaries, though this was an unusual failure, and the question was raised whether for such metals slip bands would occur before fatigue failure. Still later several laboratories both in England and in the United States observed distinct evidences of slip in certain ductile metals below the endurance limit as determined by long-time tests. It seems to-day that while slip and fatigue failure usually begin at about the same stress for wrought ferrous metals, they are two distinct phenomena, and that possibly either may occur in a metal without the other.

Fig. 1.


Specimen not Broken.
0.52% Carbon Steel (Joint Investigation)
0.55% Carbon Steel (Watertown)
Cast Steel Axle (Wöhler)
Ingot Iron (Annapolis)
Unit Stress, lb. per sq. in. (S).
Cycles of Stress for Failure (N).

Cartesian S – N Diagrams

Fig. 2.

Specimen not Broken
0.52% Carbon Steel (Joint Investigation)
0.55% Carbon Steel (Watertown)
Cast Steel Axle (Wöhler)
Ingot Iron (Annapolis)
Unit Stress, lb. per sq. in. (S).
Cycles of Stress for Failure (N).

Logarithmic S – N Diagrams

Fig. 3.

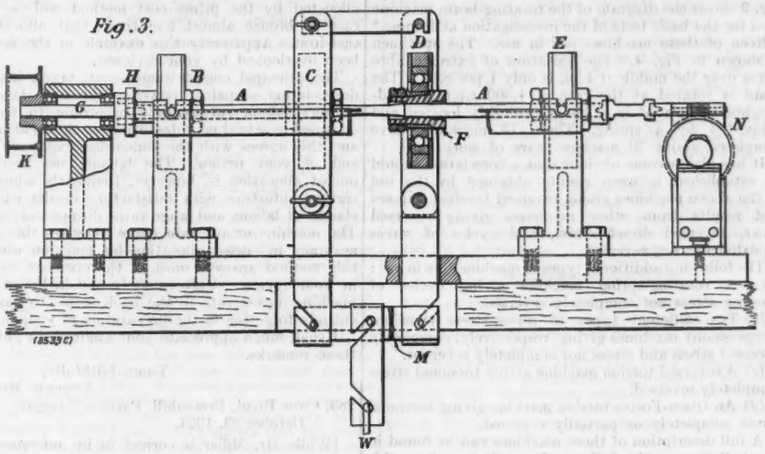
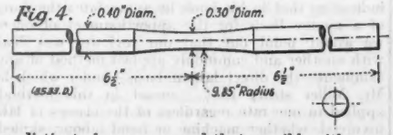


Fig. 4.



The Rise-of-Temperature Test for Endurance Limit.—Mr. C. E. Stromeyer* first used this rapid test for endurance limit, and it has been further developed by Putnam and Harsch,† and others. It consists in measuring with a delicate thermometer or a thermocouple the rise of temperature which takes place in a specimen after a few hundred cycles of repeated stress. The lowest stress for which a temperature-stress diagram shows a well-defined change of slope is reported as the endurance limit. It seems probable that this test really determines not the beginning of fatigue fracture but the beginning of appreciable slip in the crystals of the metal. This slip causes a cumulative absorption of energy, with a resulting evolution of heat. However, for wrought ferrous metals this slip seems to take place under repeated stresses slightly below those at the endurance limit, and this test seems to give reliable results for sound wrought ferrous metal (up to a Brinell hardness of about 375).

The Running-Deflection Test for Endurance Limit.—Mr. Gough‡ of the National Physical Laboratory first used the running deflection test of a rotating cantilever beam for determining the endurance limit. This test consists in obtaining a load-deflection diagram for a rotating loaded cantilever beam, using successive increments of load and locating the endurance limit at the point of departure of the load-deflection diagram from a straight line. It seems to the authors that this test, like the rise-of-temperature test, determines the beginning of appreciable slip rather than the beginning of fatigue fracture. However, this test also seems to give reliable results for wrought ferrous metals.

For non-ferrous metals, for cast metals, and for metals with many minute flaws the reliability of the running-deflection test, and of the rise-of-temperature test has yet to be proven.

Short-Time, High-Stress Tests for Fatigue Strength.—Under the urge of commercial necessity, the fatigue-resisting qualities of metals have sometimes been judged from the results of high-stress tests, using the same stress for different metals, and using the "life" of specimens as an index of fatigue strength. Such tests have proven quite unreliable even as comparative indices of the ability of the metal to withstand millions of cycles of working stress. As an illustration may be mentioned the comparative results for ordinary cold-drawn steel and normalised high-carbon steel. Under cycles of high stress the cold-drawn steel gives the longer life. Under long-time tests the normalised high-carbon steel gives the higher endurance limit. Under this head would be grouped various repeated impact tests which have been proposed. These tests may have value as acceptance tests for steel which has to withstand occasional abuse, but they certainly do not give any index of the endurance limit of a metal.

The Charpy and the Izod notched-bar tests for metal have come into rather wide use in recent years, and are sometimes said to give an index of the fatigue strength of metal. A comparison of the results of these tests with test results of long-time fatigue tests shows that whatever qualities in metal are indicated by notched-bar tests fatigue resistance is not indicated.

Recent Investigations of Fatigue of Metals Using Long-time Tests.—The use of high speed machinery, and especially the development of the internal-combustion engine and the steam turbine, greatly increased the length of service required of machine parts, and it gradually became evident that further data of long-time tests of metals under repeated stress (especially of modern steels and non-ferrous metals) were needed. In 1918 the Engineering Foundation (United States) decided to finance an extensive series of repeated stress tests, and in co-operation with the National Research Council and the Engineering Experiment Station of the Univeristy of Illinois, began the investigation of the Fatigue of Metals, with which the authors are connected, and which has been in active operation since 1919.

The original problem decided on by the Advisory Committee for the investigation by the National Research Council was the obtaining and studying of test data of a series of tests of typical steels with typical heat-treatments, and several specimens of each heat treatment of each steel tested were to be run to at least one hundred million cycles of stress. This original problem has been carried out, together with several other lines of investigation. During the progress of the investigation the following firms have co-operated in furnishing funds for the investigation:—General Electric Company, Western Electric Company, Copper and Brass Research Association, Allis-Chalmers Manufacturing Company. To date, the total amount contributed to this investigation is about 100,000 dols.

About the same time as the starting of this investigation of fatigue of metals, there was started at the United States Naval Engineering Experiment Station an extensive series of long-time tests of steel under the direction of Dr. D. J. McAdam, Jr.* In these tests also values of numbers of repetitions as high as one hundred million were frequently used.

Still more recently the United States Air Service has carried out extensive long-time tests of non-ferrous metals, paying especial attention to aluminium and magnesium alloys. These tests have been made at

* Memorandum of the Chief Engineer of the Manchester Steam Users' Association. 1913.

† Bulletin 124, University of Illinois, Engineering Experiment Station.

‡ "Improved Methods of Fatigue Testing," *The Engineer*, August 12, 1921.

* "Endurance of Steel under Repeated Stress." Chem. and Met. Eng., December 14, 1921, "Endurance Properties of Steel." Proc. A. S. T. M., vol. xxiii, Part II, page 56.

the laboratories of the Air Service at McCook Field, Dayton, Ohio, under the immediate direction of Mr. R. R. Moore.*

In the laboratory investigations carried on at the University of Illinois, long-time tests on the copper-tin-zinc alloys are now in progress, as well as tests on certain copper-nickel alloys.

It is not intended to give the impression that the three investigations named above are the only ones being carried on in the United States. Certainly the work of Gillett at Cornhill University in connection with the United States Bureau of Mines, and the work carried on at the United States Bureau of Standards should be mentioned. However, the three investigations named above have to offer as their special contribution a very considerable amount of data involving long-time fatigue tests of metals—fundamental data which it is necessary to have before it can be reasonably certain that there is an endurance limit for a given metal.

A Brief Summary of Machines and Test Methods Used in the Investigation at the University of Illinois—To a testing engineer desirous of performing a large number of long-time fatigue tests of metals, it is obvious that a battery of inexpensive machines, simple to handle, and reasonably accurate, are necessary. Fig. 3 shows the diagram of the rotating-beam machine used for the basic tests of the investigation at Illinois.† Fifteen of these machines are in use. The specimen is shown in Fig. 4. The variation of extreme fibre stress over the middle 0·1 in. is only 1 per cent. The beam is rotated at the rate of 1,500 r.p.m. Deadweights are placed in a hanger suitably located and supported by a spring. These 15 machines have completed about 70 machine-years of work.

It has also become obvious that a correlation should be established between results obtained by the use of the above machines giving reversed bending stresses and results from other machines giving reversed shear, reversed direct stress, and cycles of stress repeated but not reversed.

The following additional types of machines are in use:

(*a*) A rotating-spring machine giving cycles of bending stress not completely reversed.

(*b*) Two different types of direct-stress (tension-compression) machines giving, respectively, completely reversed stress and stress not completely reversed.

(*c*) A reversed torsion machine giving torsional stress completely reversed.

(*d*) An Olsen-Foster torsion machine giving torsional stress completely or partially reversed.

A full description of these machines can be found in the bulletins on the fatigue of metals issued by this investigation.‡

In all the work performed by the investigation at Illinois the machines have performed a total of something over 100 machine years of work during the five years in which work has been going on. More than 100 specimens have been run to 100,000,000 cycles of stress or more.

In addition to the fatigue tests there have been carried out the static and dynamic tests usually performed on metals—tension, torsion and compression tests, together with hardness, impact-tension and impact-bending tests. In addition a number of micro-photographic and magnetic tests have been performed for the purpose of studying the structure and the homogeneity of the materials used.

(*To be continued.*)

French and Italian Destroyers.—The French destroyer Orage was recently launched by the Chantiers de Blainville. There are twelve other destroyers of the same class at present under construction. Her characteristics are: displacement, 1,434 tons; i.h.p., 30,000; speed, 33 knots; radius of action at 15 knots, 3,000 miles; oil capacity, 350 tons; length, 346 ft.; beam, 32 ft.; draught, 10 ft.; armament, four 5·1-in. and one 2·9-in., (anti-aircraft) guns; six 21·7-in. torpedo tubes in two groups of triple mountings.—In Italy, the destroyer leader Tigere was recently launched at Sestri Ponente. Two other vessels of the same class are at present being built. Her characteristics are: displacement, 2,165 tons; i.h.p. 50,000; speed, 35 knots; oil capacity, 350 tons; length, 360 ft.; beam, 34 ft.; draught, 11 ft. 6 in.; armament, 8–4·7-in. guns mounted in pairs along the centre line; two 3-in. anti-aircraft guns; and four 21-in. torpedo tubes in twin mountings. She is fitted as a minelayer and carries 60 mines. The French naval papers have compared the Tigere class with their own Jaguars of 2,360 tons; and armed with six 5·1-in. guns. They claim that their destroyer leaders are the more powerful; and, as usual, lay great emphasis upon the qualities of their latest 5·1-in. guns, in which French experts seem to have great confidence.

* "Resistance of Manganese Bronze, Duralumin and Electron Metal to Alternating Stress." Proc. A.S.T.M., vol. xxiii, Part II, page 103 (1923).

† This machine is of a type used by Wöhler. The machine with two symmetrical loads and a uniform bending moment was used by Sondericker in 1892. This particular form is closely modelled on a machine used by F. M. Farmer in 1918.

‡ Bulletins 124, 136 and 142 of the Engineering Experiment Station, University of Illinois.

LETTERS TO THE EDITOR.

"TECHNICAL COSTS AND ESTIMATES."

To the Editor of Engineering.

Sir,—With reference to the review of the above which you kindly published in your issue of September 19 (page 433), I shall be grateful if you will allow me to say that similar opinions to these expressed in your review are contained in the book regarding oncost allocation.

Oncost allocation is considered in the book generally and in detail for different classes of labour and different manufactures, and guidance is given for segregation of these expenses either departmentally or for hand and machine sections (page 62). This agrees with the statement in your review that it would be sometimes misleading to combine hand and machine labour for oncost apportionment. The weakness of the prime cost method for oncost allocation, which, of course, includes money values, is shown by comparing a ship's propeller of cast-iron with a bronze one for the same job, as the relative values may be taken as one to five (page 67). Although oncost actually incurred is practically the same in both cases, the oncost allocated by the prime cost method will be in the case of bronze almost five times that allocated for cast-iron. Apparently this example in the book has been overlooked by your reviewer.

The principal oncost items—rent, taxes, insurance, depreciation, repairs, power, light and heat, and indirect labour—accumulate according to the time occupied in actual manufacturing, as shown at page 66, and this agrees with the conclusion expressed at the end of your review. The labour cost method of oncost allocation is, however, frequently adopted for certain industries with satisfactory results where the classes of labour and wage rates do not vary greatly. The machine oncost rate (page 68) gives the greatest accuracy in oncost allocation for machine work, and this method answers most of the criticism contained in your review. Unfortunately the inclusion of the machine oncost rate in the book seems to have been entirely forgotten in the preparation of your review.

I shall much appreciate your kindness in publishing these remarks.

Yours faithfully,
Andrew Miller.

283, Crow Road, Broomhill, Partick, Glasgow.
October 23, 1924.

[While Mr. Miller is correct in his references, thus indicating that in his book he appreciates the dangers of a money basis for the apportionment of oncosts, we would point out that our reviewer was dealing with another and commonly applied method of apportionment—the direct labour basis—under which head Mr. Miller states that "oncost in this method is applied in one rate regardless of the classes of labour involved, whether machine or hand labour, skilled or unskilled, journeymen or apprentices. It is found that in addition to the simplicity of this method of distributing oncost the results are generally very satisfactory." Our reviewer's point was that this method is unsatisfactory and often prevents the obtaining of accurate technical costs—the subject of the book—for reasons stated in the review. As written, it would appear that Mr. Miller recognises the influence on oncosts when the value of material varies, but overlooks that same influence when differences in the cost of labour are involved.—Ed. E.]

Water Leakage from the Upper Danube.—About a dozen miles below Donaueschingen, where the name Donau (Danube) is first given to the river formed by the junction of several rivulets, the bed of the river is in some ways so cleft or permeable that most of the water disappears and the bed is practically dry in certain seasons. This is the so-called "Donauversinkung" between Immendingen and Möhringen. The water which vanishes in that reach seems to come up again near Aach, situated eight miles to the south-east of Immendingen and at a level 172 m. (564 ft.) below the river-bed. The "Aach Topf" is a natural vertical well in which the water rushes up at such a speed that it has so far not been possible to make reliable depth determinations; the well is certainly more than 12 m. 40 ft.) deep. Since 1855 attempts have been made at different periods, the latest in the years 1922 to 1924, to prove the identity of the Danube and Aach waters. That a good deal of the Aach water comes from the Danube has undoubtedly been established by means of adding fluorescein and other salts to the Danube water, but the fluctuating quantitative relations are not settled. Geologically the district is covered by the limestones of the Suabian Jura, which are much fissured in parts; water disappears at other spots as well. Politically both Baden and Württemberg are interested in this problem, which has exercised geologists a good deal. Recently engineers have taken up the question, and various hydraulic projects are now under discussion. It is proposed to tap the Danube near Immendingen by a conduit, tunnel and open canal, which is to bring the Danube water with a head of some 560 ft. down to the Aach, where a hydro-electric station is to be erected.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—Judging from inquiries made this week at representative steel and engineering concerns, there appears to be no prospect of any general improvement in trading conditions until the feeling of unsettlement created by the Election Campaign is removed. The outlook, however, is regarded with rather more hope than has been shown for the past two or three months. This attitude of qualified optimism is supported by industrial leaders like Mr. A. O. Peech, chairman of the United Steel Companies, Limited, the biggest combine operating in this district, who told the shareholders on Monday that, though the steel trade has suffered and was still passing through the worst period ever experienced in its history, there had been a gradual and substantial improvement over the last four years, and he thought there was justification in looking with some confidence to the future. "At any rate," he added, "there is no necessity to be unduly pessimistic." One of the subsidiary companies of this combine, the United Strip and Bar Mills, Limited, two years ago began operating a plant of the most modern type for the production of steel strip and steel bars on the American principle of continuous running and mass production. To a large extent this plant was laid down with a view to supplying foreign markets, but owing to European competition it has not been possible during the past year to operate either of the two mills concerned at more than one-third of their capacity. Makers of heavy machinery are suffering from excessive charges, in which heavy rates and taxes figure prominently, in competition for new business. A large amount of engineering plant is only partially employed, though substantial orders have recently been booked for railway buffers. Machinery and implements for British colliery enterprises are in active demand, and makers of special steels and fittings are getting a fair share of the orders placed by British automobile engineers. The lighter sections continue to be moderately employed, though business in excavating implements and in tools for road repair and construction is less robust than was the case three months ago.

South Yorkshire Coal Trade.—The position has undergone very little alteration during the past week. The drop in the export of best steams continues to be an outstanding feature, though foreign purchases are still absorbing the bulk of the output. The home demand is quiet, with a slightly upward tendency. Surplus stocks of cobbles, nuts, and inferior slacks are reported to be on offer below listed quotations. Business in housecoal shows a gradual expansion due to the growth in the seasonal demand. Quotations:—Best branch hand picked, 32*s.* to 35*s.*; Barnsley best Silkstone, 26*s.* to 28*s.*; Derbyshire best brights, 26*s.* to 28*s.*; Derbyshire best house, 23*s.* to 25*s.*; Derbyshire best large nuts, 21*s.* to 25*s.*; Derbyshire best small nuts, 15*s.* to 17*s.* 6*d.*; Yorkshire hards, 21*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire hards, 21*s.* to 22*s.*; Rough slacks, 12*s.* 6*d.* to 15*s.* 6*d.* Nutty slacks, 12*s.* to 14*s.*; Smalls, 6*s.* to 8*s.* 6*d.*

Kelly's Directory of Engineers.—We have received from the publishers, Kelly's Directories, Limited, 186, Strand, London, a copy of the 16th edition of "Kelly's Directory of the Engineers, Iron, Metal and Motor Trades," which was recently published. Although the previous edition, issued in 1922, was an exceedingly valuable reference book, the new one far exceeds it in usefulness. While it is considered that a representative page of the old directory, which contained 158 entries, had 32 of them deleted, because of the changed circumstances which have developed in the two years since its publication, and 58 new entries were made, it will be appreciated that every care has been taken to ensure accuracy and completeness. Classification of the entries into counties, subdivided into towns and villages, makes easily possible the finding of the address of any concern, while the classification under trade headings is exceedingly useful in the quest of firms doing particular classes of work. A list of 10,000 proprietary names is given, as well as a key to the different grades of iron and steel, and a specification of the standard sections made by the various manufacturers. The volume must not be regarded merely as a new edition, for the directory has been so much extended and so many changes have been made in it that it must be regarded as an entirely new production. The price of the volume is 45*s.*, post free.

Wireless Beacon Station at Nash Point.—We understand from the Marconi International Marine Communication Company, Limited, that the first experimental wireless beacon station to be installed in this country is now in operation at Nash Point, between Swansea and Cardiff, having been subjected to severe practical tests over a period of six months with satisfactory results. The installation consists of a Marconi ½ kw., quenched-spark transmitter which automatically and continuously transmits its own call sign, G K D, on a wavelength of 1,000 metres, the power used being sufficient to enable bearings to be taken by ships fitted with the Marconi Marine direction finder at a distance of 50 miles. It is pointed out in connection with this installation that, in many places, the existing land stations are not sufficiently numerous to meet the needs of ships desirous of obtaining wireless bearings. Furthermore, the land stations having been erected primarily for telegraphic purposes are not necessarily suitably located for direction-finding work, and also, as they are in constant communication with ships, much interference exists which may cause confusion when attempts are made to take bearings. Hence the necessity for special beacon stations operating on a particular wavelength and located in the most suitable positions for navigational requirements.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Transactions in Cleveland pig iron continue on a very limited scale, but the restricted make is no more than meets current needs, and, as stocks are understood to be fully sold, the statistical situation is strong. Producers realising that little increase in demand is required to create shortage of supply are inclined to take a firm stand, and express the belief that their efforts to stabilise prices is likely to meet with success. The outlook as regards export trade is not encouraging, but hope is entertained that home demand will improve. No. 1 is 85*s*., No. 3 g.m.b., 80*s*., Nos. 4 foundry, 79*s*., and No. 4 forge, 78*s*.

Hematite.—Unsatisfactory accounts continue to be given of the East coast hematite branch. Notwithstanding the considerably reduced make, the output is still more than sufficient for the market, and producers are handicapped by heavy unsold stocks. Under such circumstances it is not surprising to find prices still dropping, and there are rumours that more furnaces may shortly be put out of operation. Mixed Nos. are now on sale at 87*s*., and No. 1 is offered at 87*s*. 6*d*.

Foreign Ore.—Imported ore is difficult to dispose of. Sellers base market rates on best rubio at 21*s*. 3*d*. c.i.f. Tees, and would favourably entertain offers at rather less.

Blastfurnace Coke.—Durham blastfurnace coke is in only very moderate demand. Good medium qualities are round about 25*s*. delivered here.

Manufactured Iron and Steel.—The various descriptions of manufactured iron and steel continue in poor demand, and foreign competition keeps keen both at home and abroad. Continental iron bars, and semi-finished steel materials are still being sold for use here at prices much below rates at which local manufacturers can quote. Export prices are on lower levels than the following rates, which are named for home trade: common iron bars, 12*l*.; iron rivets, 14*l*. 5*s*.; packing (parallel), 9*l*.; packing (tapered), 12*l*.; steel billets (soft), 8*l*. 10*s*.; steel billets (medium), 9*l*.; steel billets (hard), 9*l*. 10*s*.; steel rivets, 14*l*. 15*s*.; steel boiler plates, 13*l*.; steel ship, bridge and tank plates, 9*l*. 15*s*.; steel angles, 9*l*. 10*s*.; steel joists, 9*l*. 10*s*.; heavy steel rails, 9*l*.; fish plates, 13*l*.; black sheets, 13*l*.; and galvanised corrugated sheets, 18*l*., to 18*l*. 5*s*.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The reduction in the price of Scottish manufactured steel intimated here last week has not resulted in a flow of new business, and indeed it cannot be said that conditions show any change whatever. The fact is very plain that consumers are in many instances not placing orders locally, and those who are offering the cheap Continental or English material are managing to pick up a goodly share of any business passing. Despite the reduction of 10*s*. per ton, the difference in quotations between the local makes and those brought into the district is so much that the inducement to neglect the local producer is very great. The latter will get his share again, but is getting weary of waiting. The black sheet makers are not only well booked ahead, but are still being offered quite a lot of fresh business in the lighter gauges. Heavier gauges are easier and an improved demand would be welcomed. Shipments are steady and large lots of the galvanised qualities are going overseas with regularity. The market quotations are as follows: Boiler plates, 13*l*. per ton; ship plates, ¾ in. and up, 9*l*. 15*s*. per ton; and sections, 9*l*. 10*s*. per ton, all delivered Glasgow stations.

Reduction in Price of Black Sheets.—At a meeting of the Scottish Black Sheet Makers' Association it was decided to follow the reduction in the price of steel by reducing heavy gauge sheets by a similar amount—10*s*. per ton. In the lighter gauges the reduction ranges from 10*s*. to 20*s*. per ton.

Malleable Iron Trade.—The West of Scotland malleable iron trade remains very quiet, with only a moderate amount of dealing going through. Buyers are very difficult to find either on home or foreign account and the outlook continues clouded. The various makers have decided to reduce prices by 10*s*. per ton and the current quotation for "Crown" bars is now 12*l*. per ton delivered Glasgow stations.

Scottish Pig-iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, October 18, were 760 tons. Of that total 594 tons went to foreign destinations and 166 tons coastwise. For the corresponding week of last year 1,695 tons went overseas and 100 tons coastwise, making a total shipment of 1,795 tons.

Shipbuilding.—The Lloyd Triestino of Trieste have placed orders with The Clyde Shipbuilding and Engineering Company, Port-Glasgow, for two steamers, each of about 8,000 tons deadweight. Their speed will be 11½ knots and the cost is said to be about 87,500*l*. each.

Scottish Pig-iron Trade.—The pig-iron trade of Scotland is practically without change and not only is the home demand very small, but that for overseas is likewise exceedingly poor. There are no signs of any improvement in the trade, and although some fair inquiries are coming along occasionally the resultant business is often much below expectations. The upheaval in political affairs at present is not tending to make conditions any easier. Prices are dropping and the following are to-day's quotations:—Hematite, 4*l*. 15*s*. per ton, delivered at the steel works; foundry iron, No. 1, 4*l*. 15*s*. per ton; and No. 3, 4*l*. 10*s*. per ton—both on trucks at makers' yards.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—According to returns of H.M. Customs 2,024,594 tons of coal were shipped as cargo from the South Wales ports in September, compared with 1,944,651 tons in August, when there were three less working days than was the case last month. The value of the September shipments was greater than in August, amounting to 2,522,502*l*. against 2,409,594*l*. The average price per ton of the coal shipped at 24*s*. 11*d*. was 2*d*. higher than in August, due chiefly to the increased values realised for anthracite coals. The volume and value of the shipments made in August and September are shown below:—

—	August.		September.	
From—	Tons.	£	Tons.	£
Cardiff ..	1,170,252	1,423,203	1,256,217	1,530,997
Newport ..	367,391	442,415	336,982	403,391
Port Talbot ..	158,740	183,379	144,617	164,726
Swansea ..	248,268	360,597	286,567	423,388
Totals ..	1,944,651	2,409,594	2,024,383	2,522,502

Steam small coal shipped from Cardiff in September realised an average price of 17*s*. 2*d*. per ton, compared with 16*s*. 6*d*. in August, those shipped from Newport 19*s*. 1*d*. against 18*s*. 9*d*., at Swansea 17*s*. 7*d*. against 17*s*. 8*d*., and at Port Talbot 16*s*. 11*d*. against 17*s*. 5*d*. Steam throughs exported from Cardiff averaged 22*s*. 5*d*. against 23*s*., at Newport 20*s*. 5*d*. against 24*s*. 2*d*., at Swansea 19*s*. 9*d*., the same as in August; at Port Talbot 20*s*. 6*d*. against 21*s*. Steam large shipped from Cardiff averaged 27*s*. 1*d*. against 27*s*., from Newport 26*s*. 2*d*. against 26*s*., Swansea 25*s*. 11*d*. against 27*s*. 3*d*., and Port Talbot 26*s*. against 26*s*. 4*d*. Large anthracite shipped from Swansea, however, averaged 42*s*. 7*d*. against 41*s*. 2*d*., and small 23*s*. 5*d*. against 22*s*. 1*d*. Some big orders have been placed during the past week for Welsh coal for delivery over the whole of 1925. The Central Argentine Railways have contracted for 400,000 tons of best Admiralty large on the basis of 26*s*. f.o.b., which business has been followed by an order from the Midi Railways of France for 250,000 tons of coal and fuel over 1925. A special significance attaches to the French business, inasmuch as the original inquiry was for 155,000 tons, the order subsequently being increased by 95,000 tons, which suggests that the prices indicated were either lower than was expected, or that the French railway authorities are of the opinion that contract prices are likely to harden. The Midi Railway contracted for 30,000 tons of Monmouthshire large at 22*s*. 9*d*. to 23*s*. 6*d*. f.o.b., 140,000 tons of through compared with an original inquiry for 80,000 tons at 17*s*. 6*d*. to 18*s*. 6*d*., and 80,000 tons of patent fuel at 24*s*. 2*d*. f.o.b. against an original invitation for 45,000 tons. Meanwhile the general position of the market, though showing no appreciable alteration, has developed a better undertone. Supplies of most grades are still in excess of the demand, but even so sellers are not so ready to modify their quotations as has been the case during the past couple of months. Best steam smalls are certainly firmer and less freely offered, with the best grades realising up to 15*s*. 6*d*., but if taken in conjunction with large obtainable at 6*d*. less. Best Admiralty large rules from 27*s*. to 27*s*. 6*d*. with Monmouthshires from 23*s*. to 24*s*. 6*d*. and smalls from 11*s*. to 15*s*. 6*d*.

BLACKBARROW HYDRO-ELECTRIC POWER SCHEME.—The 30-ft. fall at Blackbarrow on the River Leven, 3 miles down from Windermere, already utilised for the supply of power, is to be the scene of a new hydro-electric scheme proposed by the Barrow Corporation. There are already two dams, built in connection with existing works, and the new scheme will take advantage of the first. The head race from this dam is to be extended beyond the second dam, by which means a fall of 33 ft. will be secured, at a low expenditure. Three water turbines each capable of generating 500 kw. will be installed. In the event of shortage of water supply for the turbines, the Barrow power station, which can develop 7,000 kw., will augment the energy available It is hoped to provide current at a potential of 11,000 volts for distribution to surrounding districts.

STUDY OF BRITISH "PERMITTED" EXPLOSIVES.—While British coal mines have made more progress in the application of rock dust to prevent explosions than has been accomplished by American mines, they have not been so uniformly successful in developing safe types of explosives. The Department of the Interior, through the Bureau of Mines, is to conduct tests for the English explosives testing station on British "permitted" explosives, to determine wherein they differ from the "permissible" explosives approved by the Bureau of Mines for use in gaseous and dusty coal mines. This work is being done in pursuance of an arrangement for the exchange of information between the British and American mining Bureaus, and follows the recent visit of the Director of the Bureau of Mines to England, where he studied methods employed in that country for reducing the risk of accidents in coal mines.

NOTICES OF MEETINGS.

THE PHYSICAL SOCIETY OF LONDON.—To-night, at 5 p.m., at the Imperial College of Science, South Kensington, S.W.1. "Underblown Pipes," by D. Gunnaiya, M.A., and G. Subrahmaniam, M.A., with Demonstration by D. J. Blaikley. "On the Temperature Gradient in Gases at Various Pressures." By W. Mandell, B.Sc., and J. West, B.Sc. "Vectorial Dimensions," by J. F. S. Ross, M.C., B.Sc.

THE INSTITUTION OF MECHANICAL ENGINEERS.—To-night, at 6 p.m., at Storey's Gate, S.W.1. "The Missing Pressure in Gas Engines," and "Heat Loss in Gas Engines," by Professor W. T. David, M.A., D.Sc.

THE JUNIOR INSTITUTION OF ENGINEERS.—To-night, at 7.30 p.m., at 39, Victoria-street, S.W.1. Lecturette: "Powdered Fuel," by Mr. F. F. Evans. Friday, October 31, at 7.30 p.m. Lecturette: "Audio-frequency Transformers," by Mr. H. J. N. Riddle.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Monday, October 27, at 7 p.m., at Victoria Embankment, W.C.2. Informal meeting. Discussion on "The Interconnection of Power Stations," to be opened by the President, Mr. W. B. Woodhouse.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, October 28, at 6 p.m., at Great George-street, S.W.1. Extra meeting: Address by Mr. Edgar Crammond, "The Economic Position of Great Britain."

THE INSTITUTE OF PHYSICS.—Wednesday, October 29, at 5.30 p.m., at the Institution of Electrical Engineers, Victoria-embankment, W.C.2. Lectures on "Physics in Industry," No. 7. "Electrical Precipitation," by Sir Oliver Lodge.

THE ROYAL AERONAUTICAL SOCIETY.—Thursday, October 30, at 5.30 p.m., at 7, Albemarle-street, W.1. "The R.Ae.C. Light Aeroplane Competitions," by Major J. S. Buchanan.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (LONDON).—Thursday, October 30, at 7 p.m., at the Engineers' Club, Coventry-street, W.1. Presidential Address by Mr. J. E. Anderson, followed by Lecture, "Solid Crank Axles for Locomotives," by Sir Henry Fowler, K.B.E.

SPECIFICATION FOR CAST-IRON PISTON RING POTS.—The Interim British Standard Specification for cast-iron piston ring pots (sand cast and chill cast) for Automobiles No. 5004, 1924, has now been published by the British Engineering Standards Association, and it contains besides specifications for permissible impurities in the metal, formulæ and instructions relating to testing. Copies may be had price 1*s*. 2*d*., post free, from the offices of the British Engineering Standards Association, 28, Victoria Street, London, S.W. 1.

INSTITUTION OF MARINE ENGINEERS.—A visit of the members of the Junior Section of the Institution of Marine Engineers to the British Empire Exhibition has been arranged for to-morrow, Saturday, to give them the opportunity of seeing some of the interesting exhibits, including the model of the sliding cylinder, double-acting two-cycle Diesel engine on which Mr. J. C. M. Maclagan will read a paper on December 6, which will be after the Exhibition has closed. Members are asked to assemble beside the big naval gun on the stand of Messrs. Vickers Limited, in the Palace of Engineering, at 3.0 p.m.

CONTRACTS.—The civil engineering contracting department of Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, have secured a contract, the value of which exceeds £126,000, for the first section of the Shing Mun Valley Water Works Scheme for the Public Works Department of Hong Kong. The complete scheme, which is expected to cost about £2,000,000, will be undertaken in sections, and the first involves the construction of a small intake dam on the Shing Mun river, the building of conduits, and the boring of two tunnels having lengths of 2,000 ft. and 4,000 ft. Pipe lines will be laid to provide a supply of nearly 3,000,000 gallons of water per day.—The Ransome Machinery Company (1920), Limited, are supplying the concrete mixers to be used in connection with the Sydney Harbour Bridge contract, undertaken by Messrs. Dorman, Long and Co., Limited. The firm have also secured an order for 27 steam-driven concrete mixers, complete with engines, for the Central Indian Coalfields, through the India Office.—Messrs. J. Blakeborough and Sons, Limited, of Brighouse, Yorks, have secured an order for the supply of two Larner-Johnson valves, and a set of head gates in connection with the extensions to the Lake Coleridge (New Zealand) hydro-electric power scheme.—Messrs. Barber, Walker have ordered a complete duplicate set of winding engine parts for their Harworth Main colliery from Messrs. Vickers, Limited, of Barrow-in-Furness, and their associated company, the Metropolitan-Vickers Electrical Company, Limited, of Trafford Park, Manchester.—Messrs. Thos. W. Ward, Limited, of Sheffield, have secured the contract for the supply of five miles of 6 in. steel lap-welded screwed and socketed piping for export to the Attock Oil Company, Limited, Rawalpindi, India.—The Foundation Company, Limited, acting on behalf of Messrs. Lafarge, have placed an order with Vickers Limited, Barrow-in-Furness, for the first clinker-grinding plant, comprising tube mills, installed in this country in connection with the manufacture of Ciment Fondu.—We are informed that on the recommendation of Messrs. Merz & McLellan the Government of South Africa have placed an order for three 10,000-kw. steam turbines with Messrs. James Howden and Co., Limited, of Glasgow.

CHASSIS OF THE 3-LITRE SPORTING-MODEL BENTLEY CAR.

(*For Description, see Page 579.*)

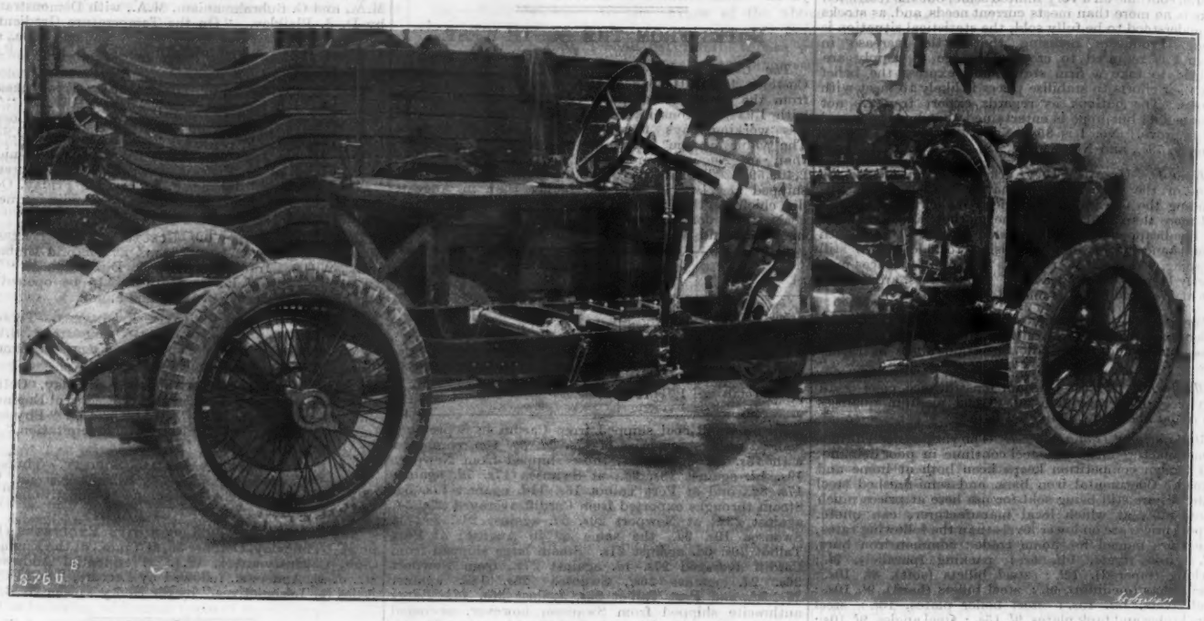


Fig. 36.

Fig. 37.

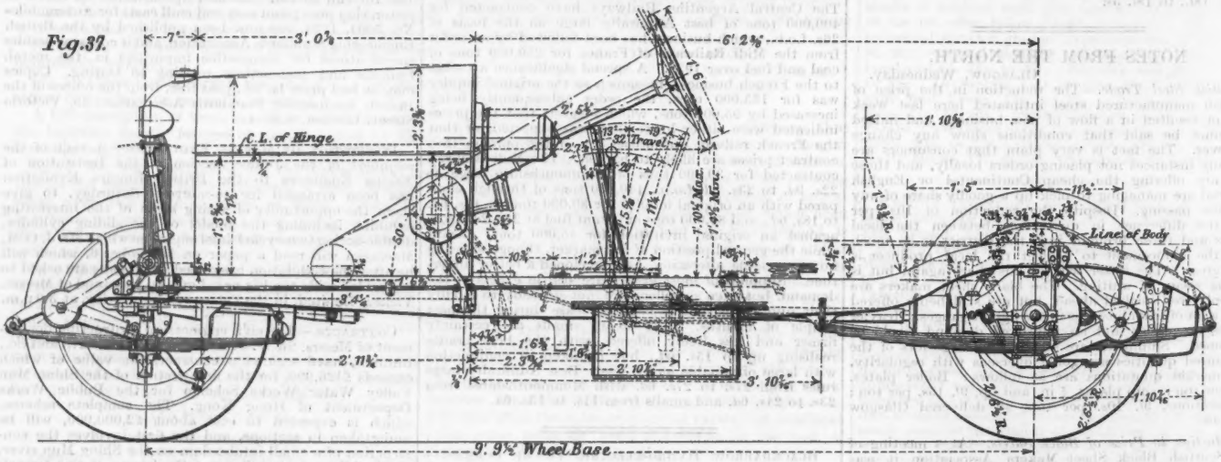
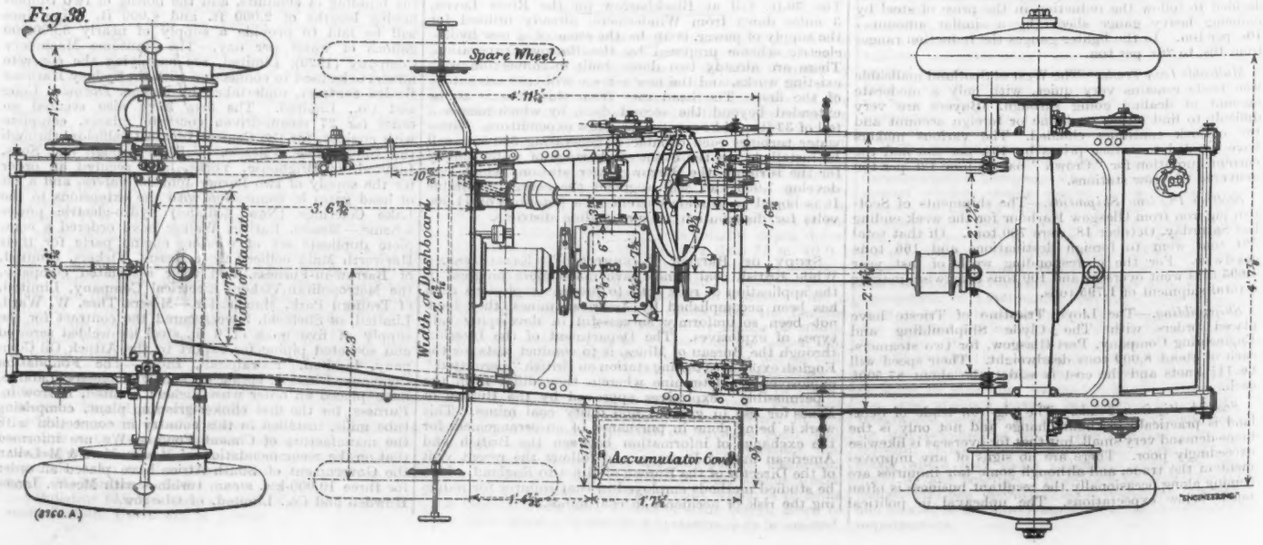


Fig. 38.



DETAILS OF 20-H.P. SIX-CYLINDER MOTOR CAR.

CONSTRUCTED BY MESSRS. ROLLS-ROYCE LIMITED, ENGINEERS, DERBY.

(*For Description, see Page* 575.)

(*To face page* 576.)

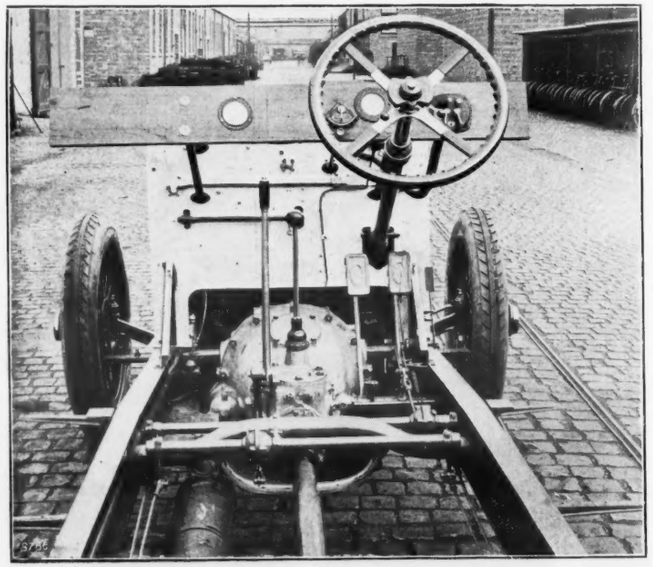


FIG. 9. VIEW SHOWING GEAR BOX AND CONTROLS.

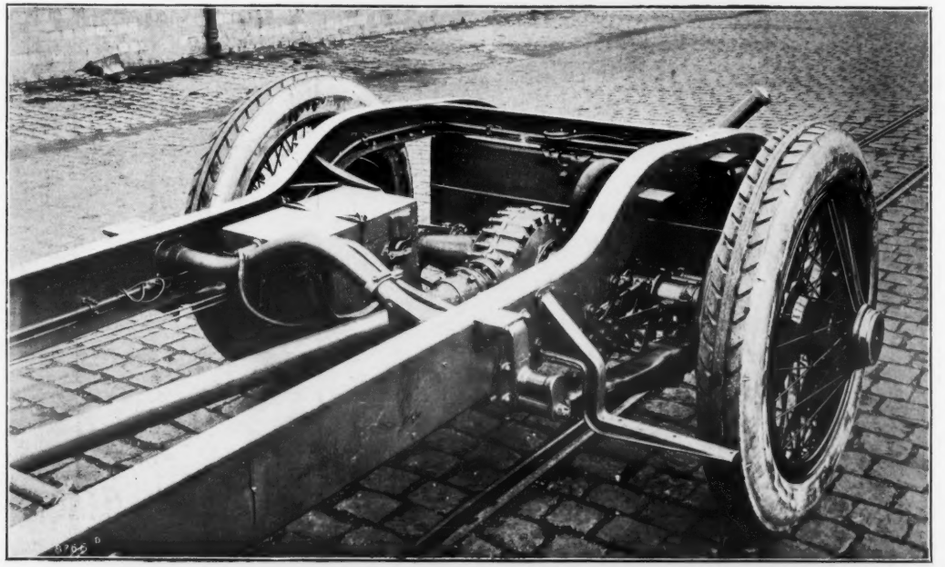


FIG. 10. REAR END OF CHASSIS.

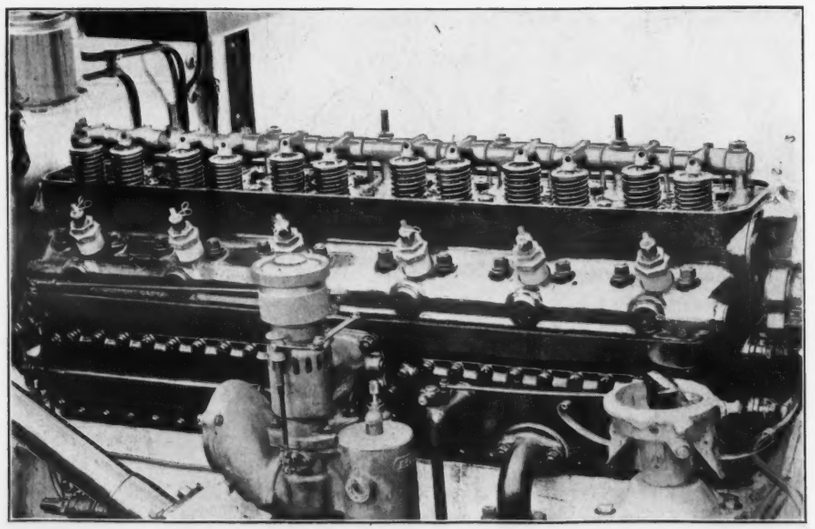


FIG. 11. ENGINE, ADMISSION SIDE.

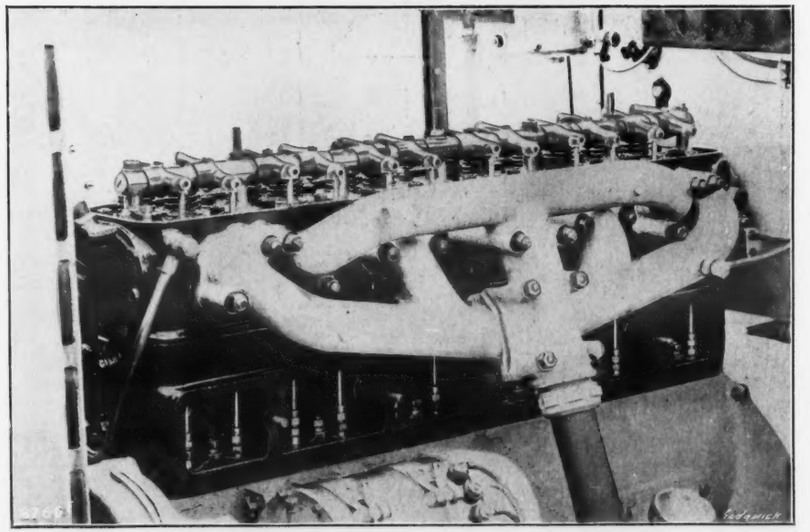


FIG. 12. ENGINE, EXHAUST SIDE.

10/25-H.P. FOUR-CYLINDER MOTOR CAR ENGINE.

CONSTRUCTED BY MESSRS. DORMAN AND CO., LIMITED, ENGINEERS, STAFFORD.

(*For Description, see Page* 577.)

Fig. 13.

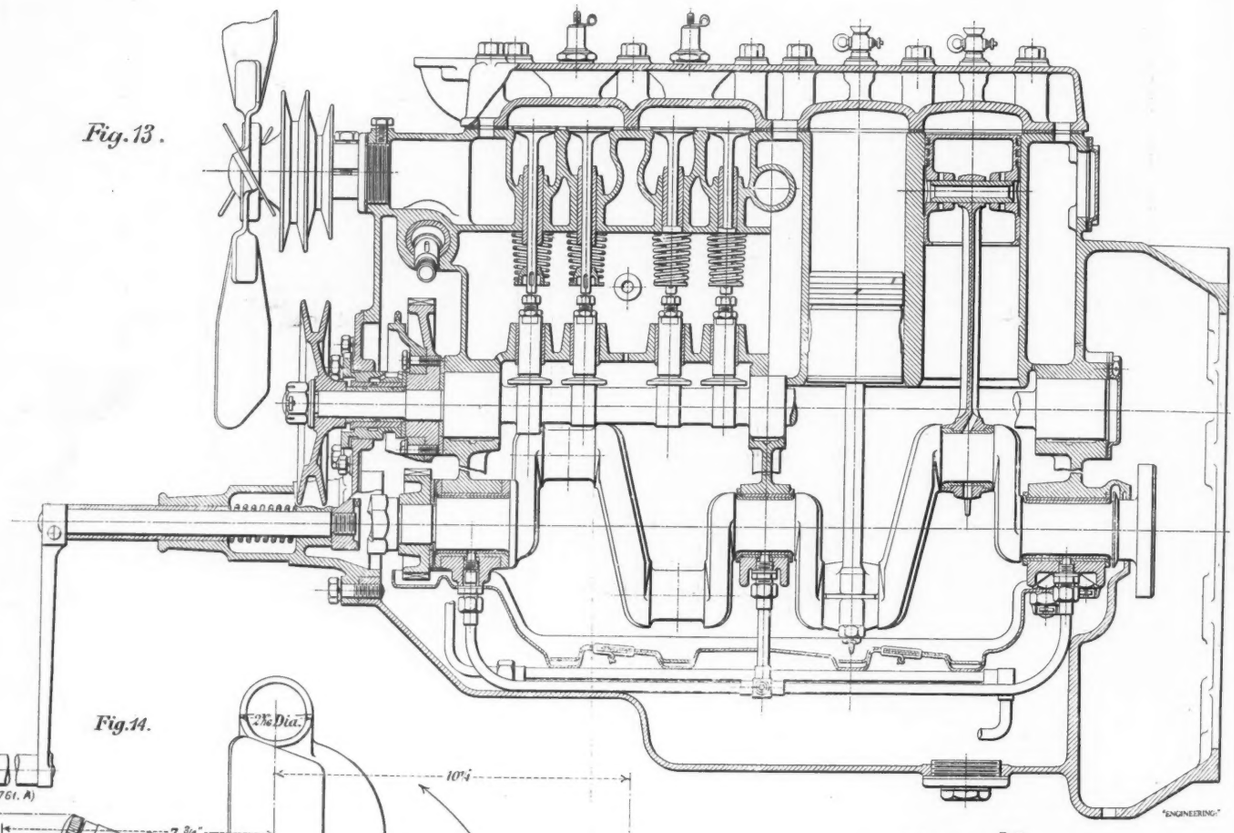


Fig. 14.

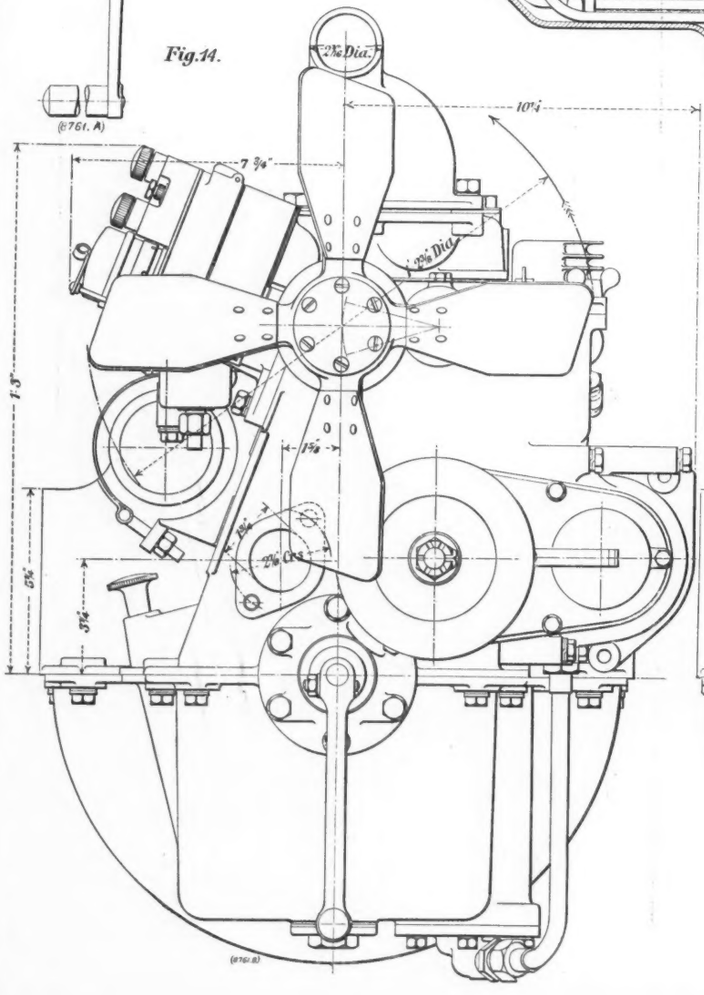
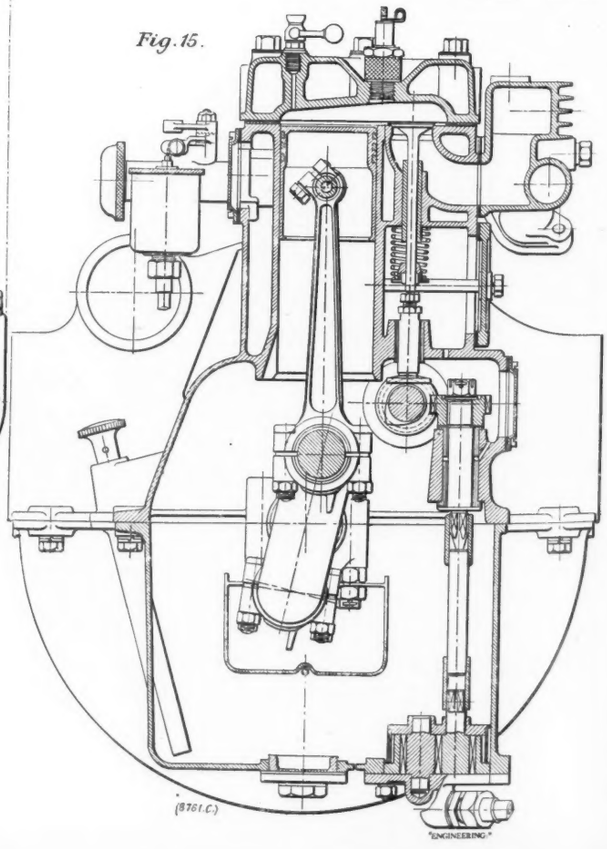


Fig. 15.



9/18-H.P. FOUR-CYLINDER MOTOR CAR ENGINE.

CONSTRUCTED BY MESSRS. DORMAN AND CO., LIMITED, ENGINEERS, STAFFORD.

(*For Description, see Page* 577.)

Fig. 16.

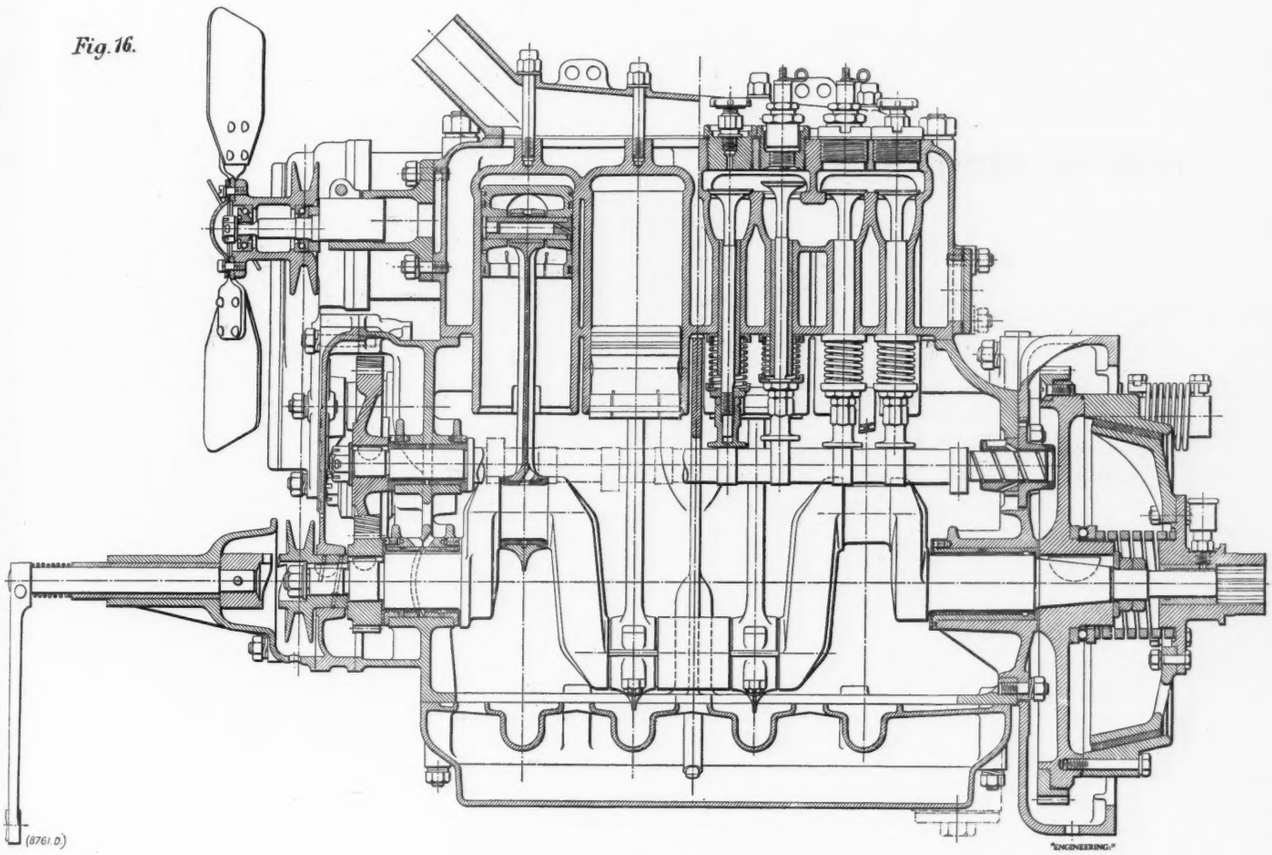


Fig. 17.

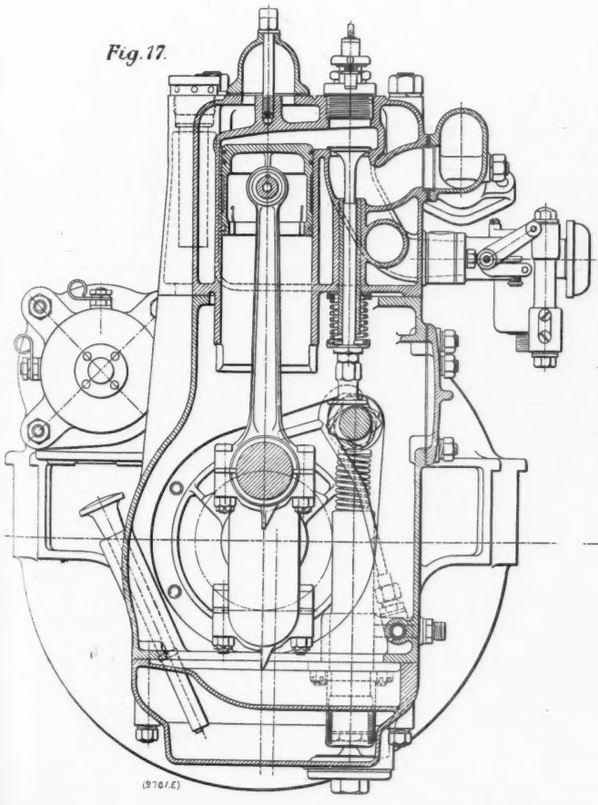
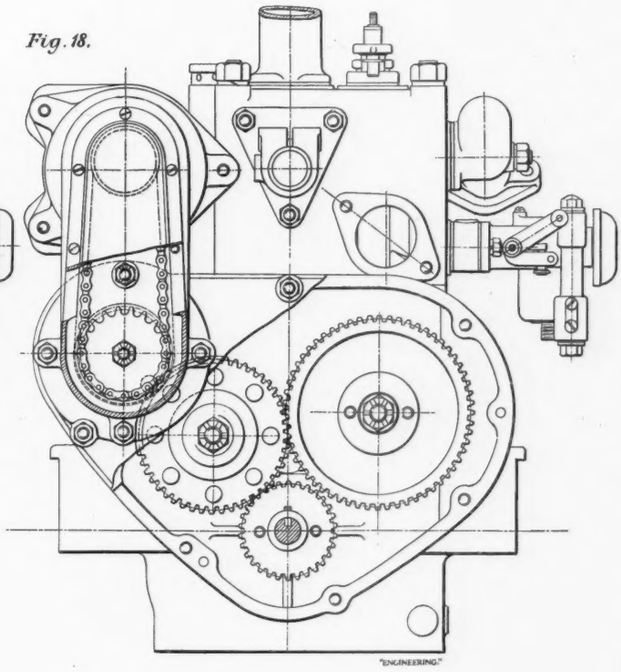


Fig. 18.



MOTOR CAR CHASSIS WITH 8/30-H.P. OVERHEAD VALVE ENGINE.

CONSTRUCTED BY GWYNNES ENGINEERING COMPANY, LIMITED, LONDON.

(*For Description, see Page* 577.)

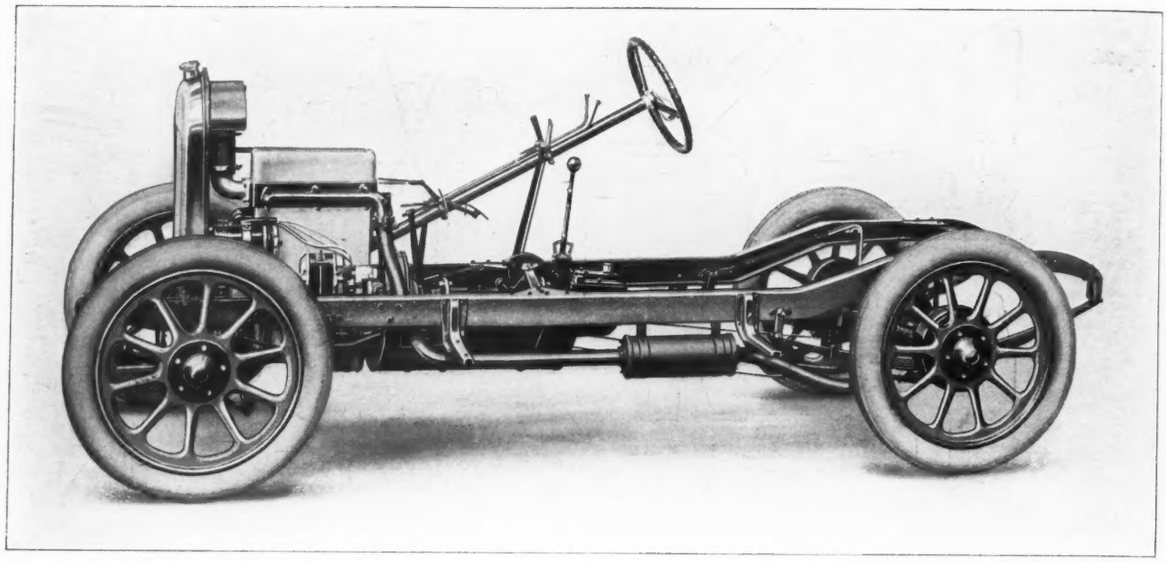


FIG. 22.

Fig. 23.

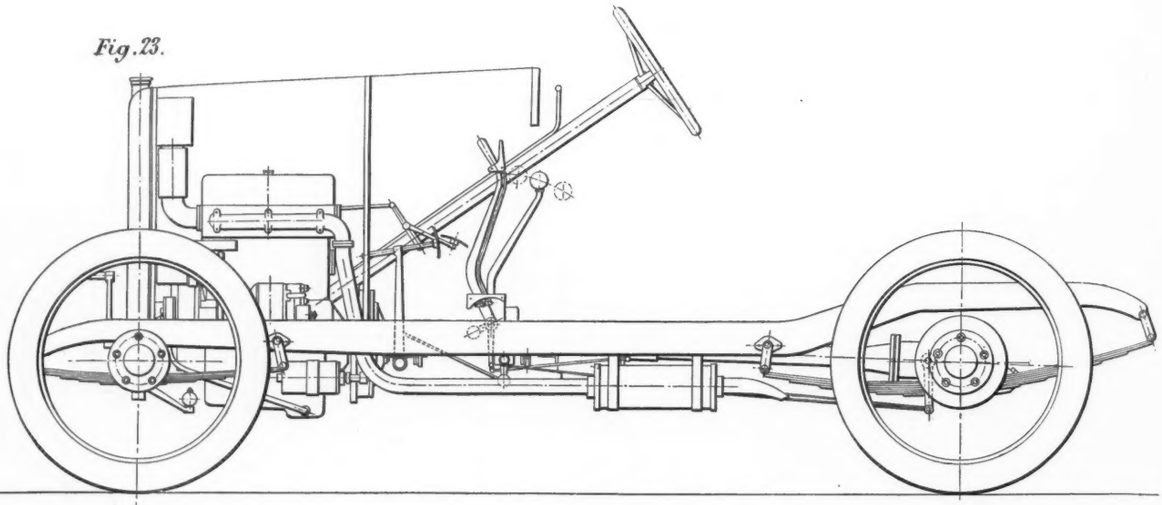
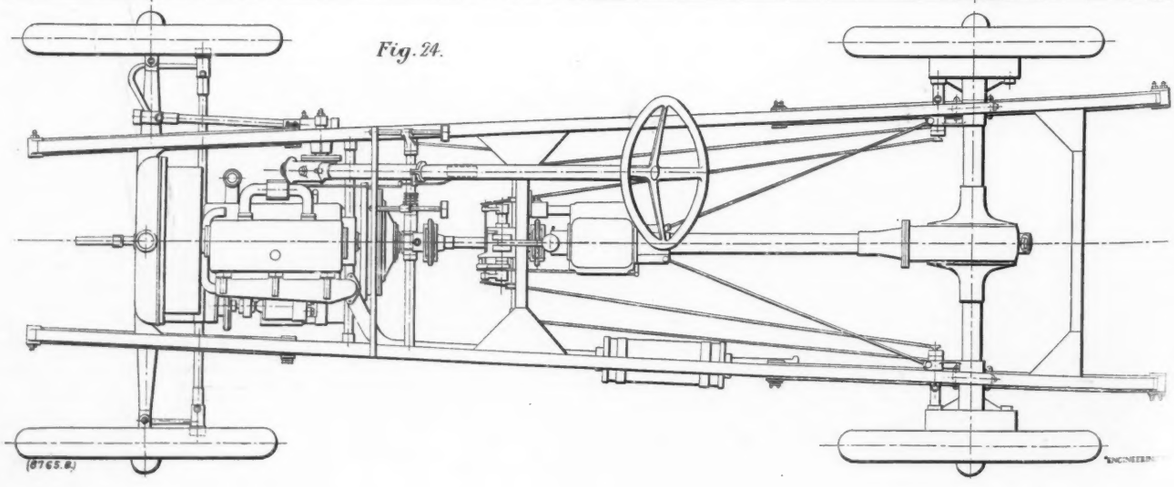


Fig. 24.



ENGINEERING.

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

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ENGINEERING.

FRIDAY, OCTOBER 24, 1924.

THE INDUSTRIAL MACHINE.

THERE has grown up amongst a certain class of thinkers, and particularly amongst those who have some drastic remedy of their own for the betterment of the world, a tendency to liken the industrial system of to-day to some huge soulless machine. Wage-earners are considered as individually insignificant details driven, like the teeth of gearing, to play their monotonous part in keeping the whole machine in motion. Their "daily round" is imposed on them by inexorable forces directed by a few men for the purpose of making wealth, which in turn is used to add further to the vastness and complexity of the machine. Such a conception of an industrial civilisation is as untrue as would be the description of a man in terms of the mechanics of his skeleton. No one will deny that there are certain cases of cause and effect to which the name of "economic laws" may be reasonably applied, but to suppose that such laws describe the whole of the forces which shape human civilisation is as foolish as to believe that the hopes, aspirations and emotions which go to make up the life of a man can be interpreted in accordance with the principles of thermodynamics or the laws of motion.

The idea of the industrial machine owes its origin largely to the writings of the earlier economists like Adam Smith, who were at pains to show that certain principles underlay the production of corporate wealth, and that these principles could not be violated without danger to the community. The mechanistic conception of the industrial structure was also fostered by the advances in physical science during the last century, which developed a materialistic outlook on life, in accordance with which all phenomena were to be explained in terms of matter and motion. Because we can tell by the laws of mechanics how a machine will move when any wheel is turned, and because chemical laws enable us to know what will happen when two substances are mixed together, it was assumed that a knowledge of the economic laws would be a sufficient guide as to the actions of men, in their relationships with each other. The facts of life, however, cannot be made to fit any such materialistic theory. The most important forces at work in the world cannot be measured in pounds, and breaking strains are mental rather than mechanical.

As Dr. J. S. Haldane pointed out in his recent presidential address before the Institution of Mining Engineers—an address which should be read and taken to heart by all those who hold administrative office—the mechanical conceptions of science break down irretrievably when we endeavour to apply them to life and conscious behaviour. Men, whether individually or in bulk, did not act as if solely impelled by their material interests. The British miners, of whom he was particularly speaking, would give loyal and efficient service, would face any danger, would forgive real or imagined mistakes, and would take the rough with the smooth, the bad times with the good, but what they would not tolerate was being treated as if they were mere tools. Neither high wages, nor welfare schemes, were sufficient of themselves to satisfy them, but only human and sympathetic treatment, as that of comrades in a common enterprise. It was one thing to make use of physical and economic knowledge, but quite another to regard this knowledge by itself as an adequate basis for management. The capital of a mining enterprise was its credit, and this depended on the mutually loyal service of all engaged in the enterprise. A working coal mine was not a mere outcome of what were called economic and physical conditions; it was the result of human co-operation and comradeship using, in its own way, and at its own free will, the tools provided by scientific and economic knowledge. Unless the relationship of all concerned with the undertaking was one of mutual confidence and thoughtfulness for the interests of all, the enterprise would be unstable and its credit or capital would disappear.

While we are in entire agreement with Dr. Haldane that the idea of the industrial machine may convey a totally false and dangerous impression of the mutual relationship of those who are engaged in industry there is a sense in which the metaphor may be justified. A machine may be regarded as something which uses energy for the production of useful output, and its perfection is judged partly by the quantity produced for a given consumption of energy and partly by its freedom from partial or total breakdowns. From this point of view any industrial undertaking may be fairly likened to a machine, the driving power being the human energy of the whole of those engaged in it, and the output being the wealth which is produced by this energy. That the energy should be, as it all too frequently is, largely dissipated by internal friction, and misunderstandings, or that the machine should stop altogether for want of mutual accommodation of its parts is deplorable in every way. The waste of energy due to internal friction can never be estimated in figures, for it is as silent as it is insidious, and the full effects of the losses caused by actual stoppage of any industry can never be accurately known.

How some of this industrial waste might be prevented was the main theme of another recent presidential address, namely, that of Mr. Tom Westgarth before the North East Coast Institution of Engineers and Shipbuilders. That two presidential addresses, both dealing with the mechanism of industry should be delivered almost simultaneously is significant of the place which the question holds in the minds of men in responsible positions. Whereas Dr. Haldane dealt broadly with the sympathetic spirit which must underlie the actions of all engaged in industry if happiness and prosperity were to be obtained, Mr. Westgarth devoted himself more particularly to the practical means of ensuring that the wheels of industry should run more smoothly. Both, however, showed an enlightened understanding of the aspirations of the workmen, and an appreciation of the factors that mould their outlook, which are the first essentials to the successful direction of industry. Mr. Westgarth held, as all do who are conversant with industry, that most of the industrial waste caused by strikes and lock-outs could be avoided by patience and goodwill and by a greater effort on both sides to see things from the standpoint of the other.

Workmen were not always to blame, and many employers failed to realise the effect on the workman's mind of a constant fear of being out of work, or worse still, that his health, which is his capital, should fail and leave him unable to provide for himself and his family.

Among the causes of waste or inefficiency in the industrial machine mentioned by Mr. Westgarth was the strict adherence of trade unions to the demarcations of work between individual trades. It would, as he said, be wiser and certainly more economical in the long run, if a certain amount of "give and take" could be exercised, but it must be remembered that the primary cause of demarcation of work is not in any way malicious, but arises from a fear of unemployment or of having a hardly-won standard of living jeopardised by competition from less skilled workers. Similarly, the restriction of output, when adopted as a deliberate policy by a workman is much more frequently due to an honest desire to conserve employment for himself or his fellows than to any wish to increase the cost of production. That restriction of output is wasteful in the extreme and consequently injurious to the prosperity of an industry and all those who live by it, cannot be too strongly emphasised, and as Mr. Westgarth said, an employer was just as much in honour bound to work hard and do his best as anyone else. The man, whether employer or workmen, who did not do a fair day's work for a fair day's pay, was no gentleman but a waster, who endeavoured to live at the expense of others.

Mr. Westgarth looked to an extension of the system of payment by results to diminish industrial waste, and considered that the system could be made to work most fairly and satisfactorily if the workmen were represented by one of themselves on the board of the company. There is a great deal to be said for workmen-directors and a great deal to be said against. As a rule, the workmen themselves are not enthusiastic about having one of their fellows on the board, and are even suspicious of the plan, while the position of the workman-director is by no means to be envied. The managing director of a firm should, if he does his duty, be quite closely enough in touch with the employees through the proper channels to present their case adequately to his fellows on the board, and he should be directly accessible to any workman or his representative when occasion demands. The ultimate solution of the industrial question will not, however, depend upon the minor details of the mechanism by which industry is carried on. It is likely to lie in the direction of providing that the wages of the workers shall be proportional to the prosperity of the industry in which they are employed, capital and labour being partners in the net earnings according to an agreed scale instead of either party striving to benefit itself at the expense of the other. This principle has been accepted by one of our largest industries and should be capable of extension. But to make this or any other system work satisfactorily requires the spirit of honesty, human comradeship and goodwill which was so strongly pleaded for in both the addresses to which we have referred, and on which the future of the whole nation depends.

EGYPTIAN GOVERNMENT HELP TO THE COUNTRY'S INDUSTRY.

The tendency of governments in many countries to attempt to extend home production and reduce their dependency on supplies from outside their territory, has now become one of the characteristics of Egyptian development. Public assurance has already been given by the first Egyptian Cabinet responsible to a Parliament, of its support of the efforts of an industrial association formed for the advancement of home trade and including in its membership representatives of some of the largest local manufacturers. In many other ways they have indicated by their actions the desire to extend home activity, whether promoted by European enterprise or not. Existing monopolies and concessions have been the cause of limited action so far, but it is unlikely that others will be easily established under the new conditions.

The membership of the Association of Egyptian Industries was raised in 1923 to 80 firms, which have a total capital of 25 million pounds. This association includes not only purely Egyptian firms but also those which are Egyptian from the legal point of view. In 1923 many concessions were obtained as the result of the propaganda work of the association. Instructions have been sent by the Ministry of Finance to the various purchasing departments advising them to give preference, where price and quality are equal, to local products when contracts are being considered. A decree was issued on July 18, 1923, authorising the exemption from import duty and quay dues of certain unspecified goods when exported, provided they are manufactured in Egypt. A drawback of seven-eighths of the import duty was also granted on the re-exportation of raw materials, which had undergone some process of local manufacture.

As far as Joint Stock and Limited Liability Companies are concerned two of the Government regulations may prove a source of embarrassment to foreign concerns. These specify the inclusion of an Egyptian on the Board of Directors and the obligation to publish balance sheets in the newspapers. We learn from a "Report on the Economic and Financial Situation of Egypt," prepared for the Department of Overseas Trade, by Mr. E. Homan Mulock, the Commercial Secretary at the Residency, Cairo, what the effect of the Government regulations has been. An attempt has been made by the three departments of the Government which are concerned with regulations regarding petroleum to introduce storage conditions of so drastic a nature that their application in their original form would have greatly curtailed all activities and might, indeed, have terminated the enterprise of the private firms concerned. Costly and non-productive adventures in search of Egyptian oil, made by a previous government, have demonstrated that prospecting and exploitation work are better left in the hands of private concerns and, therefore, it is hoped that no legislation will be put into force that will hamper the legitimate activities of the European companies. Attempts at the control of the cotton industry have twice been made and have proved entirely abortive. The application of the imposed regulations so upset the system of the sale of cotton and hampered the work of the ginneries, that the marketing of cotton was made almost impossible, and incalculable harm was done to the growers, whose interests the Government hoped to protect and benefit.

British trade has been well maintained during the period covered by the Report. In some types of goods an increased share of the business has been obtained by British manufacturers, especially in metal goods and other items of engineering interest. Imports of British iron and steel goods showed an upward tendency in 1923, but the same condition prevailed in the market for Belgium and German products. In other kinds of metal goods a slight increase was shown in the British figures, while cast-iron pipes from France and industrial tools and implements from Germany decreased. Satisfaction may be obtained from the figures for the importation of British internal combustion engines, which were double in 1923 what they were in 1922. In the same period the chief competitor, Switzerland, showed a decrease. The increase in the importation of motor vehicles, from 1,248 in 1922 to 1,543 in 1923, was principally due to the increased participation of the United States of America, who hold pride of place in both quantity and value. The French motor-cars imported were more than doubled during 1923, while British deliveries increased by 60 per cent. in number, but this was accompanied by a decline in value. British light cars have now made an appearance in the market, and it is hoped that they will command a ready sale in competition with the cheap-looking German models which are already available. Foreign competition in the coal-carrying trade is unfortunately on the increase. In view of the increased volume in 1922 and 1923 of arrivals of coal from the United Kingdom it is to be regretted that more of this important trade is not catered for by British shipowners. The long deferred extension of the port of Suez seems at last to be on the point of realisation. Tenders submitted from four firms, two of which are German, one Italian and one local, are at present under consideration.

THE CO-ORDINATION OF RESEARCH.

With the increase of independent agencies devoted to scientific and industrial research, a corresponding need has arisen for co-ordinating their work. This need is considerable already, but both in this country and the Empire it is likely to grow larger. The State is now spending substantial sums on research, but they are only a small percentage of what, in the United States, is being spent regularly every year, and has been spent for many years past. The American expenditure has not been incurred from reasons of sentiment. It was initiated and is being continued because in the judgment of that sagacious and successful manufacturing country, it is the best possible means of ensuring the progress of industry, and the constant accretion of fresh knowledge by means of which such progress can be made. The course of American industries has shown nothing to discredit this belief, or to discourage the best informed opinion in American industrial circles from continuing to give effect to it.

The United States has far greater natural resources than this country, and could much better afford the extravagance of using them inefficiently, to check which is a main purpose of research, than can our own much poorer and more densely-populated country. In export markets, moreover, the United States is among our keenest competitors; the ultimate industrial revival of Germany will undoubtedly reinforce her settled policy of scientific research; and other manufacturing countries, such as Japan, are increasingly adopting the same line of action. No Washington Conference is likely to be called to discuss a world-wide reduction in industrial armaments; and this country will be bound to accept the alternative either of increasing the assurance of progress that lies in adequate research, or of accepting the inferior position and standard of life that must result from neglecting it in the presence of better equipped competitors.

With the increase of the extent of the work the importance of co-ordinating it will increase still more rapidly, and an aspect of the annual report of the Department of Scientific and Industrial Research to which special attention should be given is that relating to its efforts in this direction. This is the more desirable because such efforts, if rightly conceived, do not lead to results that are necessarily striking or even obvious. The theory of State action that the Research Department adopted at the outset and has constantly maintained is that the State should do the least it can on work other agencies could do equally well, and the most it can to stimulate such agencies into appropriate action. By its constitution, the Department's entire proceedings are taken under the advice of a Council which is formed, recruited and renewed from outside the Civil Service.

On every important subject with which it has to deal this Council sets up a Committee, representing the highest scientific and industrial opinion that can be obtained in the country. It has instigated the formation of Research Associations with the express provision that its financial aid and its share in their control must be regarded as only temporary, to cease at the end of a short term of years, and to be given only when a sufficient prospect is shown that at the end of the term the industry itself will be able and willing to undertake and continue the work without the help of the Department. Many other Government Departments have need of scientific research; and the Research Department has now instituted and got into successful working a system of Co-ordinating Boards, by which the work of each other Department is made available as far as possible for all Departments. It has instituted a Records Bureau in which the details of its own work are placed at the disposal of all bodies and persons concerned, together with such communications as it receives from Dominion and foreign Governments and other bodies. Yet, it may be doubted whether these several and far-reaching arrangements are recognised generally at their full value in the organisation of research.

It is to be hoped, nevertheless, that this apparatus of co-ordination, the results of which appear to have been eminently successful as far as they have gone,

will not stop where they are. An extension, for instance, that seems obvious is that the function of the Records Bureau as a passive receptacle for acquired knowledge should be supplemented by an active function of directing the attention of the industries concerned to such results as would interest them if they were brought to their knowledge.

No doubt in the long run most of such results would filter into industry, in the same way as in the long run results obtained in foreign industries reach those of our own country. As a matter of practical business, however, the lag that necessarily attends this slow and irregular filtration of knowledge is a grave handicap to industry. No one who is familiar with the course of business, particularly in recent years, can doubt the advantage of an early start in any fresh development, and this advantage may easily, and even probably, be lost if an industry has to find out for itself what accessions of practically useful knowledge have been received. Such accessions do not come by themselves, unmixed with information of less or no immediate value. They are more in the nature of ores or gems, in seeking which most of the material that miners have to get may be valueless except as a vehicle for what is precious, and considerable labour is required for sorting it out before the valuable products can be obtained.

It would, no doubt, be costly to add this active function to the present passive organisation of the Records Bureau, and it is quite intelligible that, with the several successive reductions that the Department has had to make in its budget during the past few years, the present replacement of a small part of the funds it had surrendered may still leave it without the means of incurring any expense it can avoid. It is, however, to be hoped that, when its circumstances permit, it will consider the possibility of communicating to industries those results that seem likely to be of immediate consequence to them, instead of letting them wait till they have dug them out for themselves from the large volume of results having no immediate industrial importance with which they are necessarily intermixed. From another aspect it seems desirable that the dissemination of material such as is collected in the Records Bureau should involve live communication between the parties whom it concerns. Those who have attended congresses have often had occasion to note that their most useful work was done in the smoking rooms of the hotels after the day's official work was over. In these informal meetings those who had heard the papers of the days were able to get much nearer the heart of the subject and of each other's difficulties than they could in a more general and formal discussion. Where any particular bodies having different interests are represented, a more intimate exchange of opinion and, in the thermal sense, a more efficient regeneration of experience is to be obtained by such live intercourse than by merely consulting an inanimate clearing house.

A particular instance of the need for such living intercommunication presents itself in the case of the Dominions and Colonies. The settled policy of the Research Department has been to avoid, wherever possible, undertaking work for Oversea Governments, while offering its sympathetic cooperation in whatever research work such Governments might undertake for themselves. If the results of such researches as may be made in pursuance of this policy are to be felt over here, if those who are charged with them are to have the full benefit of such relevant knowledge as has been accumulated in this country, some better means will be required than the mere exchange of official letters and reports. Dominions are represented in London by High Commissioners, and the functions of these officers extend not only to political but to industrial subjects. It is no disparagement of the distinguished persons who may fill these offices to say that individually they are not likely to have technical knowledge, and the usefulness of a High Commissioner might well be increased if he had on his staff some one in the nature of a technical attaché, familiar with the conditions and difficulties of his own land, and able to take and give expert account of the results obtained in each country.

THE SAFETY OF LIFE AT SEA.

Only by having the average density of its hull, machinery and load less than that of water, can a ship be made perfectly unsinkable. When wood was the material of hull construction a close approximation to absolute security was obtainable, but as long as steel must be used for the hull, the degree of safety is determined by the resultant effect obtained from a series of conflicting conditions and thus may vary within wide limits. The risks cannot be completely removed; they can only be minimised. Watertight sub-division has made it possible to confine the flooding of a damaged ship to the region of the injury, and thus save the ship or give enough time, when the vessel is certain to founder, to call by wireless the help of ships in the vicinity and to enable the passengers to take to the boats. As a last resort lifeboats and buoyant apparatus must be provided, so that the passengers and crew may have security until help arrives. Of recent years the demand has been made for boats for all. When the possibility of a fire on board ship is contemplated, the necessity for boats for all becomes strikingly apparent. Provision of boats is not the only problem, however, which the shipowner and shipbuilders have to contend with, as the boats must be stowed in such a way as to limit the obstruction on the deck and yet be instantly available in times of necessity.

A new series of Statutory Rules and Orders relating to life-saving appliances was placed on the tables of both Houses of Parliament on August 6 and as the prescribed period of 40 days has now elapsed, these Rules will take effect. The new regulations come fully into force on July 1, 1925, and prior to that date shipowners will require to make the necessary additional provisions, which the Rules enforce. Ships are classed under the two headings of "Foreign-going" and "Home trade" for the purpose of the Rules. For each class a minimum number of davits, a minimum number of open boats and the smallest aggregate capacity of lifeboats in cubic feet are specified on a basis of the length of the vessel. For "Foreign-going" ships the Board of Trade have reserved the right to require in place of davits, or in addition to them, other forms of launching appliances in cases when it appears to them necessary, having regard to the height at which the boats are carried above the centre of the load line disc and to other circumstances. In cases where the lifeboats on davits do not furnish sufficient accommodation for the total number of passengers, arrangements must be made to the satisfaction of the Board of Trade for the carrying of additional lifeboats in such a way as not to impede the prompt handling of the boats, buoyant apparatus, or the marshalling of the people on board at the launching stations. It is provided that, as far as practicable, one additional lifeboat may be carried under each set of davits and others may be stowed on the deck, bridge or poop so as to be available for use on either side of the ship and to be so secured that they have the best chance of floating free of the ship if there is no time to launch them.

In addition to the lifeboats specified as necessary for the number of passengers carried, "Foreign-going" passenger ships are required to carry buoyant apparatus of approved design, sufficient to support 25 per cent. of the total number of passengers which the ship is certified to carry. Not only is this an important provision, which demands the immediate attention of the shipowners, as by next July the complete equipment must be available, but the conditions of the use of buoyant apparatus have been recognised and it must be capable of being thrown from the deck of the vessel on which it is stowed. This is a requirement that necessitates much greater strength than was formerly the case with buoyant apparatus. Under the old regulations, which only affected the "Home trade" a drop of 20 ft. was regarded as sufficient. Now the buoyant apparatus must be capable of being thrown into the sea from a much greater height, something of the order of three times that value, in fact. The constructors have tackled the problems of new designs to meet the additional requirements, and recent tests have shown that success has been attained.

The changes made in the regulations for the first class of "Foreign-going" vessels are those to which we have already referred, but it must also be recognised that new conditions are imposed for every class of vessel down to motor boats, which have passenger certificates. As there are four classes of "Foreign-going" ships referred to in the new rules, as well as twelve classes of ships for "Home trade," it will be apparent that all the requirements cannot be dealt with in a short article. The most exacting case has been referred to in a general way. For the complete details of the requirements for this class and the other classifications, reference must be made to "Statutory Rules and Orders, 1924. Merchant Shipping. Prevention of Accidents:—Life Saving Appliances," which can now be obained from H.M. Stationery Office.

NOTES.

France's Large Submarines for Convoy Duty.

Submarines bigger than the British L class and smaller than the K class but more powerful than either in torpedo armament, have recently been launched in France. It would seem as though this class of submarine were intended for coastal defence and commerce protection. A great many naval officers now believe that overseas convoys of merchant ships can be protected, and brought into port, in the teeth of opposition from surface cruisers, if they are defended by an escort of submarines with a powerful torpedo armament. The problem is at present in its infancy; and it would seem as though this French type were designed as the first step towards its solution. If any submarine with the same tonnage as the Souffleur were intended for commerce destruction, she would undoubtedly be given a far more powerful gun armament. The submarine Souffleur, launched at Cherbourg, is of the Requin type, which comprises six boats in all. Her characteristics are: Displacement, 1,082 tons on surface, 1,388 tons submerged; i.h.p., 2,900 on the surface, 1,800 submerged; speed, 16 knots on the surface, 10 knots submerged; endurance, 7,000 miles at 9 knots; length, 257 ft.; beam, 22 ft.; draught, 15 ft.; armament, one 3-in., nine anti-aircraft guns, with ten 21·7-in. torpedo tubes.

The Motor Industry.

At the annual dinner of the Society of Motor Manufacturers and Traders, which was held on October 16 to coincide as usual with the opening of the Motor Car Exhibition at Olympia, the President, Col. J. Sealy Clarke, gave some interesting figures indicating the magnitude which the industry has attained. The Society now comprises 95 British manufacturers of private motor cars, 90 British manufacturers of commercial and public service vehicles, 700 manufacturers of components and accessories, 100 concessionaires for the sale of foreign cars and some 1,400 firms engaged directly in the retail motor business. The total number of motor vehicles, excluding motor cycles, registered in this country is now 712,900, compared with 247,800 in 1919. Even so, we have only about one motor vehicle, including cycles, to every 40 of our population, as compared with one to every seven in America. The increase in the number of motor lorries, as compared with the 1914 figures, is about 50 per cent. Intimately connected with the question of the extended use of motor vehicles is the condition of the roads. Sir Henry Maybury, dealing with this point, expressed the hope that the heavier vehicles would soon be generally shod with pneumatic tyres, as this would have a very beneficial effect on the expense of road maintenance. The encouragement given to the more extended use of such tyres by the War Office conditions for granting subsidies to approved vehicles, would no doubt help to save the roads. The main and subsidiary roads of Great Britain aggregated 175,000 miles, in length and in spite of all the efforts which the Ministry of Transport were making, the modernisation of such a length of roads would take many years to accomplish. New roads also were wanted, and the first job of the new Traffic Committee would be to do something to improve road transportation in the London Dock area. Sir Henry further mentioned the necessity of taking steps to construct a tunnel under

the Thames east of London. This would be a costly undertaking and it would need many years to carry out, but it was our duty to take a long-sighted view and to commence the work before conditions became even more difficult.

The Trend of Boiler Design.

The paper read by Sir James Kemnal before the Institute of Marine Engineers on October 21 on "Present Tendencies of Steam Generation" left no doubt as to the attitude of the author towards the use of higher steam pressures than are usually employed. In view of Sir James's unrivalled experience in the construction of boilers, it is reassuring to find him whole-heartedly in favour of the present tendency to increase the pressures at which steam is generated. The higher thermal efficiency, which was thereby obtained, involved, in his opinion, no reduction in safety, provided that the construction of the boilers and their accessories was carried out by makers with a full knowledge of the art, and that proper care was taken to ensure the best material and workmanship. He pointed out that the ultimate tensile strength of steel rose until a temperature of 300 deg. C. was reached; this corresponded to saturated steam at a pressure of over 1,200 lb. per square inch. Furthermore, factors of safety of four or five, as normally employed, actually gave a greater margin of safety when applied to super-pressures. When working at 200 lb., for example, a factor of safety of five gave an ultimate permissible pressure of 1,000 lb., and to reach this was within the bounds of possibility. With a working pressure of 1,000 lb., however, the same factor of safety gave an ultimate safe pressure of 5,000 lb., which was almost certainly higher than could possibly be obtained with steam. Most of the extra-high-pressure boilers built or under construction had been of the Babcock and Wilcox type, which was specially suitable for such pressures. Amongst the boilers illustrated by Sir James Kemnal were those being installed at Langerbrugge to work at 800 lb. pressure with steam superheated to 750 deg. F., the 1,200-lb. boilers being installed at Boston, Mass., the 500-lb. boilers at the North Tees station, and others. He mentioned that the latter had now been working for three years without trouble. The most striking plant, perhaps, which he illustrated was a boiler which his company were about to construct for a power station on the Continent. This boiler will have 27,000 sq. ft. of heating surface, and will generate normally 220,000 lb. of steam per hour at 650 lb. per square inch. Sir James expressed the opinion that modern boiler and turbine practice enabled steam installations to compete in operating costs with oil engines for marine purposes, while the steam plant would give greater reliability and ease of handling.

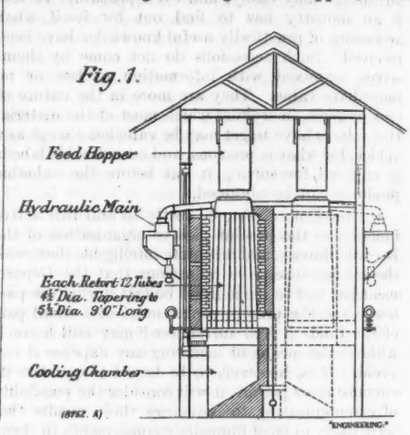
The Formation of Igneous Rocks.

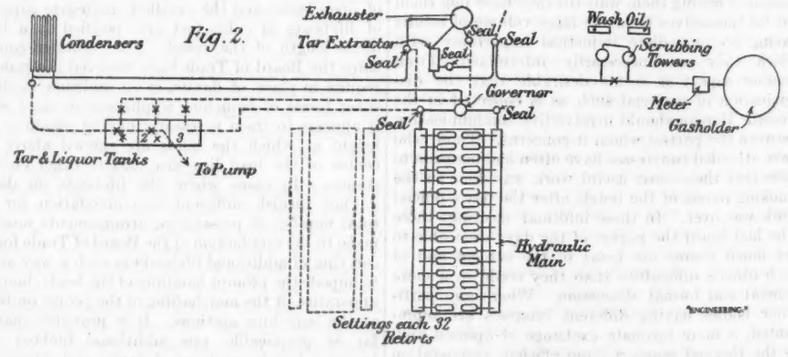
If the geologists, who are able to tell the engineer and miner where to look for water, salt, ores and oil, could also explain the conditions under which ore deposits and metalliferous veins were formed, the metallurgist might conversely learn how to concentrate and to melt or electrolyse his ores. The joint discussion on the Physical Chemistry of Igneous Rock Formation, held on Wednesday last by the Faraday Society and the Geological Society, unfortunately did not help the metallurgist much. Several of the ten very interesting papers discussed referred to ores, notably that by Professor J. W. Gregory on "Magmatic ores." But these problems, like many petro-genetic problems, remain controversial, though their study goes back to the end of the eighteenth century. Under ordinary conditions a solution and a melt are easily distinguished. When we have to deal with the high pressures and temperatures of the interior of the earth, the distinction becomes vague. The definition of a magma as a molten rock material will generally be accepted. But what magmatic ores are, is not so clear. Professor Gregory would limit the term to metalliferous ores formed during the direct consolidation of igneous magmas. Reviewing some notable ore deposits, the gold quartz veins of Victoria, the chromites of Rhodesia, the iron ores of Sweden, the nickel-copper ores of Sudbury, Canada, and the intensive pyritic massives of the Rio Tinto from this point of view he came to the conclusion that most of these deposits were formed from solutions, though the waters which deposited the primary ores were probably magmatic. As regards the Sudbury sulphidic ores in particular, which were supposed to be due to gravitational differentiation in the still plastic magma, precipitation is now generally conceded to have had a part in their genesis. Much was said at the meeting in praise of the excellent work done in the Geophysical Laboratory of the Carnegie Institute at Washington. No geophysical research is at present conducted over here, though James Hall, of Edinburgh, Dr. Flett stated in the introduction to the discussion, may be said to have laid the foundation of this science. Something might be done at moderate expense, even at relatively low temperatures and pressures in ceramic and metallurgical works, where the information gained would otherwise be useful. At the extreme temperatures and pressures to be considered, volatile products, water in the first instance, would be very important factors, though the final rock need not contain these elements. We know also very little about the contraction of solidifying metals and melts, and their other properties. Mr. Cosmo Johns and Professor Desch drew attention to these features. The latter pointed out that fused metals and silicates differ strongly as to association, viscosity and other features, and he doubted that silicates could diffuse through rocks, as distinct from percolating through fissures in them.

THE PARKER LOW-TEMPERATURE CARBONISATION PLANT.

The Fuel Research Board has lost no time in using the powers recently entrusted to it by the Government to make tests at the public expense of plants for the low-temperature carbonisation of bituminous coal. The extent, however, to which public funds are concerned in such tests is limited to the actual work of the Board's staff in supervising the trials and in making determinations of samples in the Board's laboratory. The whole of the works expenses in running the plant, taking measurements under the supervision of the Board's officers, and the like is borne by the owners of the plant, generally on the lines usual with the much less costly specification tests in ordinary contracts. It seems, therefore, that though the multiplication of tests of this sort must involve an increase in the Board's supervisory and analytical staff, a substantial part of the total cost is borne by the owners of the plant. There can hardly be two opinions as to the value on the one hand of giving those who are developing work of such national importance the benefit of the Board's unique experience, and, on the other hand, of generalising the use of large-scale measurements having the accuracy that the Board has attained in its own station and will require in such test work as it may do on other plants.

Very appropriately the first such test has been made on an installation on the system designed by the late Thomas Parker, who was the pioneer of the modern attempts to carbonise coal commercially at low temperatures. This plant has been erected at the Barugh works of Messrs. Low-Temperature Carbonisation, Limited, and as it differs from that which we described in our issue of October 28, 1921, we give in Figs. 1 and 2 diagrammatic drawings of the arrangement actually tested. The plant consists of two settings, each of 32 retorts with offtakes leading through gas valves to an hydraulic main running along the setting, and a secondary main below it to take care of gas from the coke-cooling chambers below the retorts. Each retort consists essentially of a single iron casting with 12 tubular branches each 9 ft. long and tapering from 4½ in. at the top to 5½ in. at the bottom, where the tubes are closed by an iron swing door operated by a wheel on the charging platform. Below each pair of retorts is a brick cooling chamber into which the coke is discharged from the retorts through an opening in its top, which normally is closed gas-tight. The retorts are charged through feed hoppers, which are fed from a storage hopper by scraper conveyors. An end bunker receives such coal as the conveyor carries over the top of the feed hopper, which was returned to the feed hopper towards the end of the test. The storage hopper is supplied by an elevator. The gas passes through, successively, a governor, an air-cooled condenser, an exhauster, a tar extractor, an oil-washing plant and a rotary gas meter into a 25,000 cub. ft. holder, where it is mixed with producer gas to make the fuel gas for the settings. The tar and liquor from the hydraulic mains flow through main seals into one collecting tank, and that from the condenser and the seals below the exhauster and the tar extractor into another.



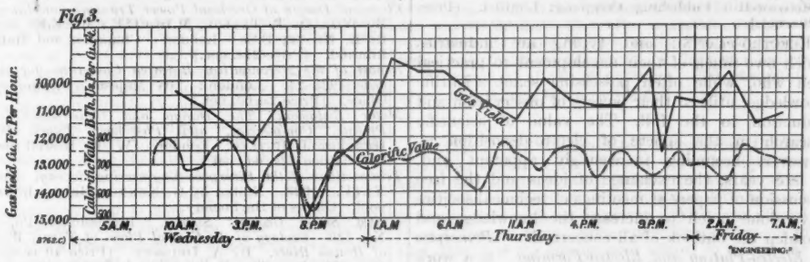


The carbonising time is about four hours, during which the retorts are charged and discharged successively in pairs. The coke from each pair of retorts is left in its cooling chamber for the four hours between charges, when it is discharged and shortly afterwards removed in skips, the breeze being left on the ground to accumulate for removal at longer intervals. The only controls on the operations seek to maintain a negative pressure of $\frac{1}{10}$ to $\frac{1}{5}$ of an inch in the hydraulic mains, and carbonising temperatures of from 620 deg. to 660 deg. C. in the retorts. In addition to a small stream of cooling water the hydraulic mains are flushed out once per shift to remove heavy tar and any coal dust, and in these trials no chokage

was experienced in the collecting system. The settings are designed for a throughput of 50 tons each per 24 hours. Only one was used in these trials, the other being shown in dotted lines. The breakage of a retort door made it necessary to shut off one pair of retorts, and the trial was therefore run on 30 retorts.

Before the test was started the plant was run until it was safe to assume—as the observations made during the trial confirmed—that it was working steadily, so that it was in the same state at the end of the trial as at the beginning, and the quantities observed during the trial could therefore be taken to represent the actual reactions that had taken place. Staff arrangements were so made that each part of the work was kept under continuous observation—24 hours a day—on much the same lines as in a steam trial. The routine observations, made periodically at predefined short intervals, measured or weighed the make and fuel gas, tar, water, coke, breeze, and calorific values and specific gravities of the scrubbed and unscrubbed gas, sampled the benzol oil wash, gas, coke and breeze, and noted the times of charging and discharging the retorts. The calorific value of the scrubbed gas was also recorded independently on a recording calorimeter. These observations were continued throughout the entire test, and in addition special observations were made from time to time of the weights of coal used and of coal carried over by the elevator, and the temperatures of the setting. At

Fig. 3.



intervals the unscrubbed gas was also washed with benzol in the works' laboratory, and samples of it and of the producer gas were taken. Observations were made at suitable opportunities on the labour employed and the working conditions of the plant. The report describes in detail the manner in which the several measurements were made. These were arranged by Engineer-Captain Shaw, Chief Engineer of the Research Station, and Mr. King, Chief Chemist. Analyses of gases were made in the works' laboratory and of other samples at the Research Station.

The coal used was Dalton Main in the form of washed smalls up to ½-in. pieces. This was one of the coals used in the Research Station experiments (see ENGINEERING, August 10, 1923, page 168), though in those experiments it had been thoroughly disintegrated and was therefore much finer. Analyses and assays in the Gray-King apparatus showed that the supply was very uniform throughout the test. In a weight balance between coal and water charged and products collected the loss was only 0·48 per cent., while the loss of heat on balancing the heat in the coal charged against that in the products was 5·2 per cent.; both figures being within those obtained in the Research Station experiments, and justifying the assumption mentioned above that the process had been proceeding steadily. These balances did not, of course, take account of any possible changes in composition in the tar and liquor in the seals, but their total volume was not large enough for any small changes to have had a significant effect on the result. For some eight days before the test the setting had been operated continuously on the same coal, for the last 48 hours under the observation of the research station staff. The test proper lasted 47 hours, during which time approximately 92 tons were put through, corresponding closely with the rated throughput of 50 tons per day for a setting of 32 retorts.

The effect of the test was accordingly to confirm the output claimed for the design. The yield of products per ton of coal carbonised were as follows: coke, 13·92 cwt.; gas, 5,620 cub. ft. or 39·6 therms; tar, 18·62 gallons; liquor, 26 gallons; crude spirit, 1·78 gallons; ammonium sulphate, 13·55 lb. It was found, moreover, that the products obtained were satisfactory both in quantity and quality, the yields other than coke averaging rather more than what had been obtained from similar coal in the Research Station's setting.* In particular the size and strength of the coke was excellent. It came out of the retort in pieces not more than 3 in. long, and two 1-cwt. bags sent on an eight-days' journey by goods train as a practical test of friability gave less than 5 per cent. of pieces that would pass through a 1-in. sieve. The coke lit readily and burned with a hot and smokeless fire, though with less flame than was shown by the Research Station coke, carbonised at a lower temperature and retaining rather more volatiles. The yield of gas was greater than in the Research Station trials, but as noted below was irregular, and the calorific value was considerably lower. Certain defects appeared in the plant in the course of the trial, which it is considered can be overcome without difficulty in future designs. The result thus establishes the fact that both low temperature fuel and the bye-products of its production can be obtained in plant of the design tested to the amounts and with the qualities claimed for it. For what period they can be obtained without interruption can only be decided by prolonged working, and what may be the commercial value of the process must depend both on this and on local and other market circumstances.

The observations made during the test showed clearly that it had been conducted under unnecessary disadvantages of design and construction. The plant was intended, for example, to work at a temperature of 650 deg. C., and to give an approximately steady yield of gas, corresponding to the very gradual method of charging and discharging. Fig. 3, however, shows that the average temperature rose as high as 800 deg., and fell below 550 deg., the average of the whole being well above 650 deg., while the output varied from 9,500 to 15,000 cub. ft. per hour. These variations, which were checked by measurements of the temperatures of individual retorts and combustion chambers, were attributed in part to imperfect design of the combustion chambers, in part to bad heat insulation, and in part to a layering separation of the rich gas from the lean producer gas with which it was mixed. With the first two defects remedied, it is thought that no addition of producer gas would be required, and the thermal expense would be greatly reduced.

* It must be remembered, however, that the station worked at notably lower temperatures than those of the Barugh test.

LITERATURE.

Marine Structures, their Deterioration and Preservation. Report of the Committee on Marine Piling Investigations of the Division of Engineering and Industrial Research of the National Research Council. By WILLIAM G. ATWOOD and A. A. JOHNSON. Published by the National Research Council, Washington D.C., U.S.A.

THE destructive influences at work on structures under sea-level have long been remarked and deplored, yet definite and trustworthy evidence concerning the rate and manner of deterioration has not been collected and analysed. Similarly, the degree of protection afforded by counteracting agencies over a length of time is not known, while on both subjects an amount of conflicting evidence exists. Accurate records have been wanting, and so keenly was the need for information felt, that the Institution of Civil Engineers, on their own initiative undertook vigorous and far-reaching investigations into the rate and extent of deteriorations of structures exposed to the action of sea water and the insidious attacks of marine organisms. The full results of that investigation will not be accessible for some years, and it is therefore satisfactory to find that other authorities are prosecuting similar enquiries. The United States National Research Council, having organised a scheme for determining the amount of injuries effected by Marine borers on wooden piles, now publishes a very full report, embracing enquiries into the efficiency of measures of protection, and the possible substitution of other materials than wood, where such piling is necessary. The scheme, which owes its origin to attention being directed to the damage occasioned by marine organisms on wood piles in San Francisco Bay, has been extended to embrace the harbours on the East and West of the Continent, and on some of the West Indian and Pacific Islands. The Committee of Enquiry is influential, embracing engineers, biologists, chemists, and specialists in wood and concrete preservation. Ready assistance has been furnished by many well-known authorities in physical science and natural history.

It was early found that while much general information existed regarding marine borers in timber and in rock, very little was known of the species, occurrence, habits, capacity of destruction, ecology, &c., with the accuracy required as a basis for searching enquiry. Consequently, a preliminary biological survey was directed to determining with precision the necessary information, and much interesting material was collected concerning the habits and method of working of the Molluscan and wood-boring Crustacea, that will be of use in related investigations, though the practical results more immediately effecting commercial activities will attract greater attention.

It is often claimed that certain woods, generally of tropical origin, are immune from attacks by marine borers. Such claims deserve and have received great attention, for importation of such foreign timber might solve the difficulties. The examination has been thorough, and specimens have been included which, though reported as attack-resisting, could hardly be regarded as structural timber. The conclusion is that no timber can be regarded as immune from attack under all conditions. Some turpentine wood, Angelique and Manbarklak from Dutch Guiana, show great resistance, but these have not been under observation a sufficient length of time to justify the claim in its entirety. Cottonwood has enough promise to warrant further examination, though its lack of strength unfits it for structural work. Neither has the cause been discovered which confers on certain timbers partial immunity. In the particular case of the Guiana timbers, it is thought that a minute silica content affords protection, in other examples resistance may be due to the presence of an alkaloid. In the case of greenheart, which has rendered such good service at the Liverpool Docks, the alkaloid berberine is regarded as the protective influence, but in tropical waters greenheart has not maintained its reputation. Whether the protective element is chemical or mechanical, its protective quality is likely to vary according to the conditions of growth, and this might explain the great difference of decay sometimes observed in contiguous structures under practically the same conditions.

In the absence of any timber absolutely self-resisting to marine attack it becomes important to enquire what measures can be taken to afford protection or, alternatively, to seek for adequate substitutes for timber. Such problems will resolve themselves practically into a compromise between the original cost of the timber and that of its protective treatment, the permanency of the structure, and the cost of replacing the injured piles in heavy structures. Where harbours are not heavily infested, turpentine wood, if the cost is not prohibitive, is recommended as promising a comparatively long-lived and economical structure. If comparative permanence is unimportant, unbarked piles may be used, but extreme care is necessary in handling and banding before the pile is driven, and knots and blazes should be covered with metal. Success can be secured only by

preventing all access to the timber under the bark. Built-up piles of layers of boards, with tar or felt intervening, are of little service, and the long-practised method of charring and tarring is found to have no appreciable value as a protection against borers. Far better is the sheathing of piles with creosoted boards, securely nailed, or the use of brush treatment with creosotes or carbolineums whose efficiency has been repeatedly tested.

More complete protection, with necessarily greater expenditure, is afforded by "pile armours," whose principle depends on the adoption of a mechanical method to prevent the borers coming in contact with the timber. A sheathing of iron, zinc, copper or Muntz metal is usually employed, but the sheathing is subject to abrasion, or easily torn by drift. In the "Perfection" process an attempt has been made to substitute for metal, coverings of burlap, soaked in crude asphalt, slaked lime, and some other ingredients likely to confer stability or longevity, the burlap being attached to the pile by spiral wrappings of 12 or 14 gauge galvanised wire about 3 in. apart. The difficulty of placing such timber without damage to the armour is considerable. The Moran process is a combination of impregnation and sheathing, the impregnating material containing iodide of arsenic as a toxic ingredient. Good reports are not wanting, but longer service is necessary for testing. Concrete casings may be expected to give a fair protection if the concrete be dense. The use of the cement gun is recommended to secure this end.

Impregnation with various materials has long been practised, and in cool waters creosote gives good results. Toxic salts have been tried, but however destructive these may prove to animal life, their protection to a pile can prove effective only so long as the dissolving and chemical effect of sea water does not reduce their concentration below the lethal toxicity required. Wherein the peculiar value of creosote exists, and whether a high naphthalene content is beneficial, is undetermined. Analysis of creosote from old piles gives little information, because so little is known of the creosote originally used. But the conclusion of the committee after very exhaustive examination is, that if the creosote be of the best quality and the impregnation be thorough and the timber undamaged by handling, this form of impregnation is the most efficient method in use at present.

Among substitutes for timber, concrete may be considered as the most economical and satisfactory, though the ordinary Portland cement deteriorates on submersion, owing to the chemical action of the sulphates in the water on the constituents of the concrete, and also on account of the mechanical action of water and drift. The most active disintegrating element in sea water is magnesium sulphate which combines with the free lime in the concrete, leaving a deposit of calcium sulphate crystals. These, occupying a greater space than the lime, produce disintegration. A cement now on the market, in which a finely ground siliceous material as pozzuolana is added, reduces the effect, and in other kinds of concrete on trial the cementing compounds are calcium aluminates instead of calcium silicates, but further experiments are needed to determine the best mixtures and proper methods of handling. With reinforced concrete, in addition to the deterioration of the concrete from chemical causes, the effects of corrosion of the reinforcing itself are to be feared. The products of corrosion expand and cause splitting, bringing other troubles in its train, easily perceived about high water level. Steel structures have as good a record as concrete, but are usually more expensive. If the corrosion of steel can be prevented by the use of alloys, it would prove a most desirable constructive material. Cast and wrought iron are eminently suitable for marine structures, and where conditions are favourable for the use of such materials, it is probable that cast-iron structures will have longer life than those built of any other material now used for the purpose.

An important enquiry has been set on foot in connection with the chemical Warfare Service, with the view of discovering chemical compounds that are definitely toxic to marine borers. This enquiry is still proceeding, but the Committee suggest the use of eleven compounds, all of which have a marked effect on Limnoria and other organisms. The best all-round specific toxic found was chlorvinyl arsenious oxide, a modification of the war gas "Lewisite." It is suggested pending further enquiries, that the addition of diphenylchlor arsenious oxide and some other toxics to the creosote used for impregnation purposes would afford lasting protection for piling. It is hoped to perfect a method of using toxic dyes in water solution, which will obtain the desired depth of impregnation, be fast in sea water, and give good results. On the other hand, a process for the destruction of marine borers on piling, depending on the generation of chlorine around the piling by the electrolysis of sea water, is found to have only a slight toxic effect on mature teredo.

A very valuable addition to the Report is the information collected from many sources, giving the history of attacks by borers on various structures. The materials on which their reports are founded represent not only the work of the Committee, but embrace the views of engineers and experts best qualified to express an opinion. They contain a wealth of information, and taken in connection with the extensive bibliography provide a survey of the whole range of the destructive work of marine organisms and the problem of the durability of maritime structure.

Principles of Electroplating and Electroforming (Electrotyping). By W. Blum and G. B. Hogaboom. London: McGraw-Hill Publishing Company, Limited. [Price 20*s.* net.]

Electro-plating and typing are industries which owe much of their development to practical men who, while often possessing scant scientific knowledge, utilised their powers of observation and deduction to the full. The value of scientific research in the sphere of electro-deposition is, however, becoming increasingly apparent and, of late years, the exchange of ideas and the free discussion of papers at meetings of technical socities have done much to increase the knowledge and broaden the outlook of all concerned. "*Principles of Electro-Plating and Electro-Forming*" is a work written by scientific men for scientific men. Even such subjects as the cleaning of greasy metal and the general preparation of surfaces prior to plating are viewed from a scientific standpoint—and rightly so. Generally speaking, all problems dealt with are subjected to the closest scrutiny and the theoretical reasoning of the authors is always sound. "Electro-forming" is evidently a newly coined word, and is defined as "the production or reproduction of articles by electrodeposition." Factors governing the character of deposits, for example, current density, concentration, temperature, and throwing power of solutions, are discussed in very able fashion, as are those factors which determine the usefulness and durability of electro-deposited metal, *i.e.*, thickness, distribution, adhesion and the like.

Having fully dealt with the whole subject in a general way, the authors turn to the consideration of each metal separately. The sections devoted to the deposition of copper, nickel and silver are very thorough, and much detailed information is supplied. Other sections deal with the plating of cobalt and iron, zinc and cadmium, and lead and tin, respectively, while the subject of alloy plating is discussed in a short chapter. In each case the compositions of plating solutions, typical of the kind used in current works practice, are given and, in addition, suggested compositions are put forward for use as bases for devising electrolytes to meet particular needs. Here, again, the scientific aspect of the subject is kept well in view, and the function of each constituent present in the depositing bath is thoroughly discussed. The authors advise frequent analyses of electrolytes for purposes of control, and the methods given for the rapid estimation of important constituents are a sound feature. Throughout the work the more scientific "c.g.s." units are quoted, and their use strongly advocated, but, in order to facilitate matters for practical men, the corresponding "English" values are, in all cases, given side by side.

The opening chapters are devoted to a very rapid outline of the theory of chemistry, physics and electro-chemistry. The principles of chemistry and elementary physics, for instance, are crammed into one short chapter of 22 pages. The authors define "matter," and pass on so quickly that within four pages they are discussing chemical notation and calculations. Valency, oxidation and reduction, electrolytic dissociation, acids, bases and salts, and other equally intricate subjects are also set out in this section. The elementary principles of analysis, of electricity and of electrochemistry are discussed with the same rapidity, and one cannot help feeling that the authors have endeavoured to condense too much in the short space of eighty pages. The definitions are, however, couched in very apt language and certainly bring out the salient points of the various branches of science involved in the electro-plating industry.

The book is, in some respects, typically American; practically the whole of the information given is gleaned from American sources. Nevertheless, the subject is well handled, and the work deserves to be as well received by English platers as it will no doubt be by their American confrères.

BOOKS RECEIVED.

Empire Forestry Journal. Vol. III. No. 1, July, 1924. London: Empire Forestry Association. [Price 4*s.* net.]

Fortschritte im Waagenbau. By Erich Dinse. Berlin: V. D. I.—Verlag G.m.b.H. [Price 3 marks.]

The Original Book of the Ford. By R. T. Nicholson, M.A. Ninth edition. London: Temple Press, Limited. [Price 2*s.* 6*d.* net.]

Electrical Design of Overhead Power Transmission Lines. By William T. Taylor, M.Inst.C.E., M.I.E.E., and R. E. Neale, B.Sc. London: Chapman and Hall, Limited. [Price 21*s.* net.]

Report of the Aeronautical Research Committee for the year 1923-24. London: His Majesty's Stationery Office. [Price 2*s.* 6*d.* net.]

Motor Bodywork. The Design and Construction of Private, Commercial, and Passenger Types. By Herbert J. Butler. London: W. R. Howell and Co. [Price 52*s.* 6*d.* net.]

Transactions of the Liverpool Engineering Society. Vol. XLIV. 1923. Edited by G. Kenyon Bell. Liverpool: Offices of the Society.

United States Geologic Survey. Professional Paper No. 126. *Geology of the Coastal Plain of Texas, West of Brazos River.* By A. Deussen. [Price 40 cents.] No. 132—D. *The Evolution and Disintegration of Matter.* By F. W. Clarke. [Price 10 cents.] No. 132—E. *An Early Eocene Florule from Central Texas.* By E. W. Berry. [Price 5 cents.] Washington: Government Printing Office.

The Institution of Automobile Engineers. Vol. XVIII. Part I. Report of the Empire Motor Fuels Committee, embodying other Allied Researches. London: Offices of the Institution.

Tables of Steel Compound Girders. Compiled by F. M. Mason. London: Chapman and Hall, Limited. [Price 10*s.* 6*d.* net.]

Factory Lay-Out and Progress. By W. J. Hiscox. London: Sir Isaac Pitman and Sons, Limited. [Price 7*s.* 6*d.* net.]

Radiotechnik. I Allgemeine Einführung. By J. Herrmann. Berlin and Leipzig: Walter de Gruyter and Co. [Price 1·25 gold mark.]

Eisenhuttenkunde. I Das Roheisen. By Dr. Ing. M. v. Schwarz. Berlin and Leipzig: Walter de Gruyter and Co. [Price 1·25 gold mark.]

The Greater Problems of Industry. By Alexander Ramsay. Birmingham: "Journal" Printing Offices. [Price 3*s.* 6*d.* net.]

United States Coast and Geodetic Survey. Special Publication No. 100. *Effect of Variations in the Assumed Figure of the Earth on the Mapping of a Large Area.* By W. D. Lambert. [Price 5 cents.] Washington: Government Printing Office.

How to Drive a Motor-Car. Eighth edition. London: Temple Press, Limited. [Price 2*s.* 6*d.* net.]

Alternating-Current Rectification. A Mathematical and Practical Treatment from the Engineering View-point. By L. B. W. Jolley, M.A. London: Chapman and Hall, Limited. [Price 25*s.* net.]

Elektrische Zugförderung. By Dr. Ing. E. E. Seefehlner. Second edition, revised and enlarged. Berlin: Julius Springer. [Price 11·45 dols.]

Aeronautical Research Committee. Reports and Memoranda. No. 899. *Determination of Scale Effect on the Centre of Pressure of R.A.F.* 14, *BE2C, Biplane with Three Values of Stagger.* By the Aerodynamics Staff. Royal Aircraft Establishment. [Price 1*s.* 6*d.* net. No. 910. *A Theory of Thin Aerofoils.* By H. Glauert. [Price 9*d.* net.] No. 912. *Stresses in a Stiff-jointed Polygonal Frame under a System of Parallel Loads. Part II.* By A. J. Sutton Pippard, D.Sc. [Price 3*d.* net.] London: His Majesty's Stationery Office.

Hints and Tips for New-Comers to West Africa. By "Bushman." London: John Bale, Sons, and Danielsson, Limited. [Price 2*s.* net.]

Combustion in the Gas Producer and the Blast Furnace. By Dr. A. Korevaar. London: Crosby, Lockwood and Son. [Price 15*s.* net.]

Das Gesetz des Kraftverlaufes beim Stoss. By Dr. Ing. Franz Berger. Braunschweig: Fredr. Vieweg und Sohn, Akt.-Ges. [Price 9 marks.]

LABOUR NOTES.

ONE of the "objects" of the National Minority Movement—in other words, the Red International Labour Union—is, it will be recalled, the formation of Factory Committees. Shop Stewards' Committees already function, of course, in the engineering industry under agreement with the federated employers. But the R.I.L.U. has apparently no use for organisations of that character. A writer in *The Worker* describes them, as a matter of fact, as "empty organisational forms—mere shadows of what they should be." What the R.I.L.U. means when it talks about Factory Committees is, according to this writer, "that in every mine there should be a Pit Committee, in every workshop, a Workshop Committee; in every garage a Garage Committee, in every ship a Ship's Committee and so on." Every worker, no matter what the age, sex, colour, creed or race is, "is to be organised and brought within the protecting power of the Factory Committee of the concern for which he or she is working" and "the living soul of the Factory Committee" is to be "the class struggle." "The duty of all militant workers is," the writer of the article from which we are quoting goes on to declare, "to infuse into these committees the life-giving spirit of the class struggle—to make them truly function as aggressive working class instruments. The fear of the sack, we know, causes many workers to shrink from participation in the work of the Committees. . . . We must create the conditions which will make it certain and definite that not a single worker is hired or fired without the sanction of the Factory Committee."

The suggestion that no worker should be engaged without the sanction of the Factory Committee is not so novel as it, at first sight, appears to be. As we noticed last week, membership of a trade union affiliated to the Trades Union Congress is a condition of employment with the Co-operative Wholesale Society. In the mining industry open campaigns against non-unionists are common, and elsewhere—in engineering, for example—much the same kind of thing is going on, though for an obvious reason, less is publicly said about it. Men in arrears with their contributions to their union as well as men who are by choice, non-unionists, are having their lives made very difficult. Whether a worker belongs to a union or not is a matter which quite properly ought not to concern employers, from whose point of view the only applicable tests are character and capacity. Trade unionists, of course, do not think so, and refuse to regard their dissent as a sign of weakness. Yet a sign of weakness it unquestionably is, for if Trade Unionism, as it is organised to-day, were the attractive thing it is claimed to be, there would be no need for campaigns against non-unionists or strikes against the employment of non-unionists involving employers in serious losses. The cure for the trouble lies in the organised worker's own hands and is to make Trade Unionism irresistibly attractive—if he can. It is no business of an employer's whether a man is a trade unionist or not, and the sooner there is clear realisation of that in Labour circles the better will it be for everybody.

A rise of 4 points in the cost of living is officially recorded for the month of September. At October 1 the average level of retail prices of the commodities taken into account in the statistics compiled by the Ministry of Labour (including food, rent, clothing, fuel and light and miscellaneous items) was approximately 76 per cent. above that of July, 1914, as compared with 72 per cent. on September 1, and 75 per cent. a year ago. The rise in the percentage during last month was due to increases, largely seasonal, in the prices of food. For food alone the average increase over the pre-war level was 72 per cent. at October 1, as compared with 66 per cent. a month earlier, giving an increase of 6 points.

According to the *Ministry of Labour Gazette*, among the 11,500,000 insured workpeople in Great Britain and Northern Ireland the percentage unemployed at September 22 was 10·8, compared with 10·6 at August 25 and with 11·7 in September, 1923. Among the members of those trade unions from which returns were received the percentage unemployed was 8·6 at the end of September, compared with 7·9 at the end of August. The total number of applicants for employment registered at employment exchanges at September 29 was approximately 1,205,000, of whom 915,000 were men and 220,000 were women, the remainder being boys and girls. At August 25 the total was 1,152,000, of whom 876,000 were men and 203,000 were women, and at October 1, 1923, it was 1,285,000, of whom 955,000 were men and 244,000 women. The principal industries showing a decline in employment in September were coal and iron mining, pig-iron manufacture, iron and steel manufacture, and the clothing trades. In the cotton, wool, textile, building, brass, and pottery trades some improvement was reported. Employment was good in the tinplate, steel sheet, brick, carpet and jute trades, with mill-sawyers and with most of the skilled operatives in the building trades; and fair in the tailoring, silk, leather, furnishing, printing and pottery industries, and in certain branches of the metal trades. At iron and steel works and in the engineering and shipbuilding industries it continued bad.

The trouble between the Amalgamated Engineering Union and the Bristol Channel ship-repairing employers was settled on October 20, the men agreeing to accept the advance of 5*s.* per week in two instalments accepted by the other trades in August. The A.E.U. men have been idle in resistance of the proposal since August 18. In the light of this news some comments on the stoppage by Mr. James, the Union's organising delegate in South Wales, are interesting. "Strange it is," he writes in the *A.E.U. Monthly Journal* for October "that when cessation of work operates through dispute, there always arises the desire for peace; the abnormality soon loses its fascinating triumph between the parties in dispute, and others not in dispute become affected, and a superlative effort is sought to end it. Why the same tolerant forbearance and exercise of mind capacity, the same human feeling, is not exercised to prevent the contingency happening always perplexes me. Surely it is better to be wise beforehand than await after events, with all their stress, hardship, and suffering—to wait until the dominant spirit which brought them about subsides into sweet reasonableness." The little homily is intended, of course, for employers. But, in this instance, all that the employers did was to intimate that after a certain date their establishments would be open to the fitters on certain terms and conditions negotiated by the men's leaders and accepted by all the other trades. The precipitate action was, in fact, taken by the A.E.U. men.

Another of the Amalgamated Engineering Union's organising delegates—Mr. Dewar, whose headquarters are at Edinburgh—is perturbed at the way in which some of the members under his care have let him down in negotiations with an employer. What was alleged to be a "wages error" came under local discussion at Kirkcaldy, and the management offered to submit the issue to a committee of 12 of their employees who were members of the Amalgamated Engineering Union. Mr. Dewar accepted the offer. "Owing to our inability," he now writes, "to secure the services of 12 fellow-workers to act in the required capacity, the matter still remains unsettled. It is regrettable," he goes on to say, "from every point of view that our members should fail us in this way, and is all the more regrettable when one remembers that the proposed committee was the suggestion of their own employer."

The Special Tribunal set up under the National Joint Industrial Council for the Electricity Supply Industry to consider the application of the workers for an all-round advance of wages has now reported, and its report is to be considered at a meeting of the Joint Industrial Council in London on November 14. The principal finding of the Tribunal is that no case has been made out for the granting of the demanded advance of 10*s.* per week, but that the district councils should be asked to reconsider their existing rates of pay in certain conditions. The increased level of wages above that of 1914 is declared to be in excess of the increased cost of living, and the level of wages in the electricity supply industry, as compared with the wages paid in the principal industries using electrical power, higher than the average, though not so high as in some cases referred to at the hearing. Generally, moreover, the conditions of employment are more secure.

In its report, the Tribunal points out that in the case of Metropolitan local authority undertakings the gross surplus represents a sum equivalent to only 4·09 per cent. on the invested capital, and in the Provinces the gross surplus represents 3·06 per cent. Gross surplus is stated to be the percentage before anything has been put to reserve or applied to the relief of rates or the reduction of cost to the consumer. Of the 14 Metropolitan companies the average net yield for the year 1922 or 1923 was 5·13 per cent., and that for the Provincial companies 4·14. The information relating to the 14 power companies showed that "the return on the capital invested in these companies has never at any time been extravagant. Most of them, if not all, have statutory restrictions placed upon them in respect of their maximum dividends. Further development is only possible by the expenditure of further capital, and this can only be attracted if the investment gives a fair and adequate yield." The average return of ten power companies from the beginning of operations to December 31, 1923, was 3·43 per cent., and their average return during the five years preceding that date 4·3 per cent. Omitting two of the companies which had been badly hit, the average return of eight power companies for the same period of five years was 5·29 per cent.

The Tribunal admits that some undertakings might not find it difficult to pay the wages increase asked for, but the claim was a national one, and it did not appear that the industry could pay an additional £754,000 per annum in wages "if the undertakings are to remain financially sound and capable of meeting the deterioration and obsolescence of plant and other needs of a recurring nature. The extra wages could only be met by imposing extra charges on the consumer. The Tribunal points out, further, that ability to pay is not the only factor, and that the other factors include the necessity of avoiding the infliction on other trades, and, especially in these days, on productive and export trades of extra cost which will be likely to reduce their ability to compete in the home or world markets. The addition of anything to the price of electrical power would have a serious effect upon these industries and also militate against the progress of the electricity supply industry itself, for it was quite erroneous to say that this industry had an open field.

An argument submitted by the trade union representatives was that the increase in wages asked for would amount to only one-twentieth of a penny per unit of power. The Tribunal points out that that is equal to an addition of 5 per cent. to the cost of generation and distribution, and that by the clauses in contracts at least one half of it would be automatically imposed on the consumer, and so would in the aggregate represent a substantial burden upon industries suffering from depression. In regard to the district reductions, the Tribunal says that, assuming the complaint to be well founded, it would not justify a uniform national increase for all workers in all areas.

In accordance with the decision of the National Committee at York, in May last, the Executive Council of the Amalgamated Engineering Union have completed negotiations with the National Council of Labour Colleges for the provision of educational facilities for the members of the union. Classes are held by the National Council of Labour Colleges in all the principal industrial areas, and where it is not possible to send tutors, outline lectures for the use of study circles are provided. According to Mr. Smethurst, the General Secretary of the Amalgamated Engineering Union, the classes deal only with subjects of especial interest to trade unionists. "They aim," he writes, "to make Trade Unionism a matter of intelligent conviction. If you want to understand the system of society in which you live; if you want to comprehend the forces that bring about unemployment, enforced emigration, poverty and wars; if you want to count in the struggle for working-class emancipation, then join the classes in your district." In plainer language than Mr. Smethurst uses, the object of the education for which the members of the A.E.U. are now about to pay, is to prepare the workers for the "class war." Up till now, the A.E.U. has been a supporter of Ruskin College, Oxford.

The Ministry of Labour reports that the number of unemployed persons on the registers of Employment Exchanges in Great Britain, on October 13, 1924, was 1,210,200—915,300 men, 36,900 boys, 225,300 women, and 32,700 girls. On October 6, 1924, the total number of unemployed persons was 1,215,575—917,847 men, 37,176 boys, 227,621 women, and 32,931 girls—and on December 31, 1923, 1,285,623—946,521 men, 36,659 boys, 267,373 women, and 35,070 girls.

On October 21, the Short-time Organisation Committee of the Master Cotton Spinners' Federation decided to extend the mill working hours in the American section from 26½ to 32 as from November 3. Mr. John Pogson, the Secretary of the Federation, in communicating the result of the meeting stated that the position would be brought under review from week to week. Before the meeting at which the extended working hours were decided on there had been an interview between the Short-time Committee and representatives of the Cotton Spinners' and Manufacturers' Association at the request of the latter, when strong representations were made to the Master Spinners' Federation as to the difficulties which many manufacturers are experiencing at the present time in securing certain counts of yarn to meet urgent present requirements. The federation committee promised early consideration of the complaint. The tentative extension of American cotton spinning production is a result.

SOCIETY OF GLASS TECHNOLOGY.

The first meeting of the Society of Glass Technology for the session 1924–25 was held in Sheffield on October 15, the President, Col. S. C. Halse, being in the chair. An address entitled *The Present Position of the Glass Industry in North America*, was given by Professor W. E. S. Turner, D.Sc., who observed that in America the period of trade depression had not been continuous, as was the case in the United Kingdom. In the autumn of 1922, American trade began to improve, and 1923 was a good year. In February, 1924, trade in general began to fall off, and a very dull period still persisted. The cut-glass industry had almost entirely died out in America, but coloured glass was finding a place more and more. There was a distinct improvement in American taste in glassware. At the Steuben Works of the Corning Glass Company some very fine artistic work was being manufactured. Professor Turner next referred to the gradual disappearance of pot furnaces in favour of tank furnaces. The latter were now being used even for the manufacture of green and blue signal lights, and for selenium ruby glass. Electric light bulbs, except in the case of very small or very large bulbs, were now practically all made by machines fed from tank furnaces, the glass being of the soda-lime-magnesia type. The tubing required for the completion of the lamp was still of the glass variety.

Several noteworthy advances in the glass industry were then noted. During the past few years there had been a very distinct development in the use of blowing machines, or press and blow machines. In this connection reference was made to (1) the Westlake machine for thin walled tumblers; (2) the Hartford-Empire machine for electric light bulbs; and (3) the great development in the manufacture of light walled tumblers. Dealing next with sheet glass, Professor Turner remarked that the Fourcault process had not as yet achieved any considerable success in America. The cylinder process was still in active operation. An epoch-making process was that developed at the glass works of the Ford Motor Company. This process marked an absolute departure from the use of pot furnace, as the glass was melted in tanks, and there was continuous rolling between a pair of rollers, the sheet passing down a lehr about 440 ft. long and subsequently, in sheets, traversed long tables in a continuous belt, where the grinding and polishing were done. With regard to bottle machines there was a tendency to replace the Owens machine in favour of the feeder type. There were no striking advances in feeding devices, the Hartford Empire feeder being the most in favour, followed by the W. J. Miller. One novelty in operation was the use of a rotating plunger, especially when large ware was being made. Professor Turner then dealt with the problems of furnaces and furnace efficiency. This was one of the foremost problems discussed by glass manufacturers. The average life of a tank furnace operated by machines was 11 to 13 months. A table was presented showing for a number of factories the value of the weight of fuel consumed to glass melted. Several factories could show a ratio as low as 0·6. In conclusion reference was made to the innovation of the use of heatless lehrs. A description was given of such lehrs.

Automobile Shock-Absorber Contest.—A programme has been received containing details of the regulation tests by which motor coach shock absorbers will be adjudged in the forthcoming competition to be held under the auspices of the Ville de Paris, at the Département de la Seine for this purpose in March, 1925. Competitors may be of any nationality represented in the League of Nations, and those interested should procure a copy of the programme and conditions of the tests from l'annexe Ledru-Rollin Quai de la Rapée 98, Direction des Travaux (Secretariat-Bureau No. 121) Paris.

Institution of Naval Architects.—The following scholarships in Naval Architecture and Marine Engineering have been awarded by the Council of the Institution of Naval Architects:—Naval Architecture: Beardmore Scholarship (150*l.* per annum for three years) to Mr. W. M. McKitterick of Harland and Wolff, Belfast. Fairfield Scholarship (150*l.* per annum for three years) to Mr. R. G. S. Kennedy, of Scotts Shipbuilding and Engineering Company, Greenock. Marine Engineering: Weir Scholarship (150*l.* per annum for three years) to Mr. G. G. McDonald, of G. and J. Weir, Glasgow.

The Ferrantians.—In November, 1912, there was held in London a reunion of Old Ferrantians, that is, those engineers who were associated with the pioneer work of Dr. S. Z. de Ferranti. It was hoped at that time that such a meeting could be arranged every year but the war intervened and nothing has since been done. It is now felt that there should be another reunion and it is hoped to hold this early in December, 1924, at the Hotel Cecil in the form of a dinner at which it is expected Mr. C. H. Wordingham will preside. All old Ferranti men who were connected with Dr. Ferranti previous to 1905 are requested to communicate with the Hon. Secretary, Mr. W. E. Warrilow, 40, Mildred-avenue, Watford.

TRANSPORTATION OF LARGE CUPOLAS.

THE TRANSPORTATION OF LARGE CUPOLAS.

The illustration above represents a pair of large cupolas recently built by the Constructional Engineering Company, Limited, of Charles Henry-street, Birmingham, loaded for transport to Bonnybridge in Scotland. Each cupola when complete will be 50 ft. 6 in. high, with a shell diameter of 7 ft. 6 in., and will weigh approximately 13½ tons. The cupolas are fitted with special air-belts 9 ft. 6 in. diameter by 8 ft. high, and are designed for mechanical charging, the charging hole being 8 ft. 8 in. high by 4 ft. 2 in. wide. These air-belts are to be seen on the truck in the foreground of the photograph. The tuyers, eight in number, are fitted at the bottom of the air-belt, the blast inlet being at the top of the belt. The cupolas are built of $\frac{7}{16}$-in. and ¾-in. mild steel plate, the bases are of similar plate 1-in. thick, and the drop doors of equal thickness. Loaded in sections, of course, the transportation presents no special difficulty, the two air-belts being easily accommodated on a flat car designed for a distributed load of 15 tons.

ROYAL METEOROLOGICAL SOCIETY.

The opening meeting of this society for the present session was held at 49, Cromwell-road, South Kensington, on Wednesday, the 15th inst., with Mr. C. J. P. Cave, M.A., president, in the chair.

Mr. Lewis F. Richardson, B.A., F.Inst.P., read two papers. The first was on "*The Brown Corona and the Diameters of Particles.*" He stated that as a result of experiment the following variety of Airy's formula had been found to be in rough agreement with measurements on various holes and spheres:—

$$(\text{diameter of obstacle}) = -\frac{5{\cdot}3 \times 10^{-5}\ \text{cm.}}{\sin\left\{\begin{array}{c}(\text{radius of chestnut-brown corona}) \text{ minus} \\ \frac{1}{2}\ (\text{radius of source})\end{array}\right\}}$$

In view of Ray's work, this would not be applicable to the smallest cloud-droplets of 2 microns diameter; but was more likely to apply to drops of ordinary size of, say, 5 to 20 microns diameter. The fundamental difficulty was that the natural coronæ, which it was proposed to interpret, included so many that showed only the vague brown ring.

The second paper was on "*Photometric Observations on Clouds and Clear Skies.*" The purposes of the communication were as follows:—To describe the improved instrument which was made at Benson; to give an account of experiments which proved that the difference of brightness at the moon's limb, as measured by the instrument, was independent of the glow of the sunlit sky; to bring to notice some new facts showing that the transparency of blue sky altered during twilight; to set in a list with dates the photometric observations of clouds under separate headings corresponding to two theories applicable to clouds which did and did not hide the sun; to compute the rainfall equivalent to the cloud on those occasions when a corona revealed the size of the droplets; to compare the two theories in the special instance of clouds to which they could both just be applied; to correct the theory for uniform opaque clouds to make it agree with the other; and, finally, to note that a certain very dark thunder-cloud was like a rain-factory holding in stock only one hour's output.

Mr. L. J. Sutton, M.A., A.Inst.P., submitted "*Notes on Haboobs.*" This note was a discussion of such information as had been recorded by meteorological observers in the Sudan or obtained from other authentic sources. Haboobs were severe sandstorms of a type apparently confined almost entirely to the Sudan, where they were most frequent in the central region. Nearly all of them occurred during the rainy season, *i.e.*, May to October, and at Khartoum, for example, they were experienced more than once a week during this period and lasted about three hours, on the average. Haboobs probably owed their origin to the heating up of a large region for four or five days, but, owing to the wide distances between meteorological stations in the Sudan and the meagre information available, the author had been unable to discover where any particular haboob originated or to follow its track.

"How to Drive a Car."—The eighth edition of the motoring handbook, "How to Drive a Car" written by the editor of *The Motor*, has now been published by The Temple Press Limited, 7-15, Rosebery Street, London, E.C., at a price of 2*s.* 6*d.* net. The volume does not deal in detail with the mechanical features of motor-car construction, but is intended, as its title implies, to provide instruction and advice on the art of handling a car. The treatment of the subject is interesting and extremely simple throughout, and the novice undergoing instruction in driving should find the book useful.

The Cost of Coal-handling in Power Plants.—By the courtesy of the Underfeed Stoker Company, Limited, of Aldwych House, Aldwych, London, W.C.2, we have received figures relating to the cost of handling coal at the Lakeside Station at Milwaukee, where pulverised coal is employed for boiler firing. In view of the difference between labour costs in Great Britain and America, comparison are best made on the basis of the man-hours of operating labour spent per ton of coal consumed. The Milwaukee figures are given separately for the 27 months from February, 1922, to April, 1924, inclusive. The smallest monthly coal consumption was 13,047 tons in June, 1922, and this was handled from the car-dumper hopper to the boiler ash-hopper at the cost of 11,188 man-hours, or 0·85 man-hours per ton. The greatest consumption recorded, namely, 25,620 tons in March, 1924, was handled for a cost of 0·54 man-hours per ton. During the whole of the year 1923, 236,873 tons of coal were burnt, and the operating labour in the pulverising house and the boiler-house amounted to 138,678 man-hours, or a average of 0·585 man-hours per ton. These figures presumably do not include any time spent on repair or maintenance of the pulverisers, elevators, conveyors, driers, feeders or other apparatus, and of course to arrive at the true economy of the system the interest on the capital cost must be taken into account. It should be mentioned that the convenient short ton of 2,000 lbs. as used in America is employed above.

THE SYNCHRO-BALANCE INTERNAL-COMBUSTION ENGINE; EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. BLACKSTONE AND CO., LIMITED, ENGINEERS, STAMFORD, LINCOLNSHIRE.

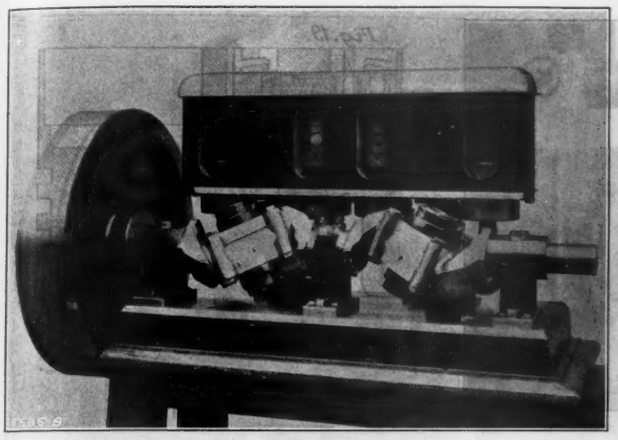


Fig. 1.

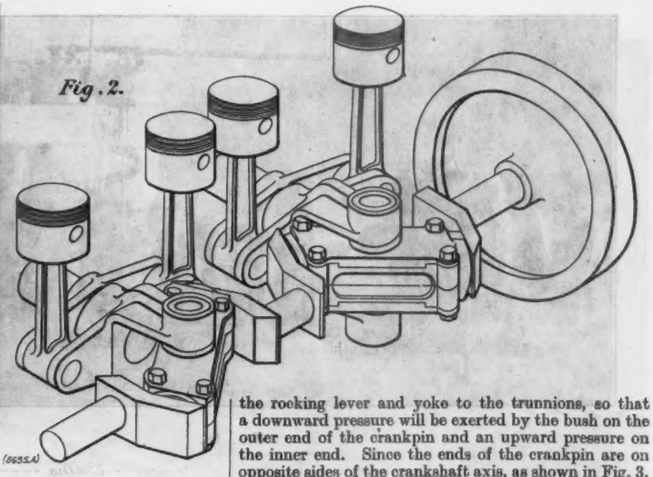


Fig. 2.

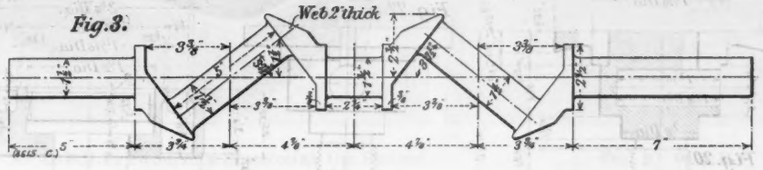


Fig. 3.

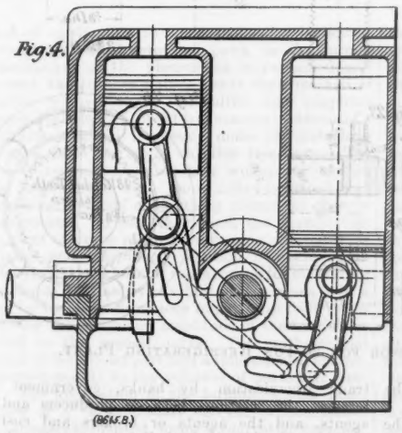


Fig. 4.

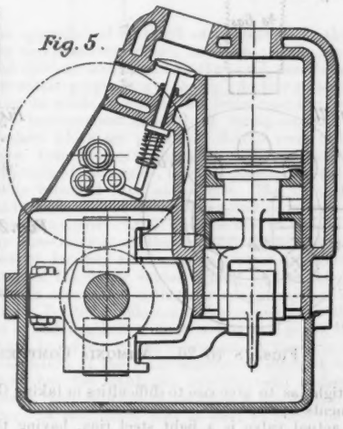


Fig. 5.

THE BLACKSTONE SYNCHRO-BALANCE INTERNAL-COMBUSTION ENGINE.

In an article in our issue of July 4 last, on page 22, describing the engineering exhibits at the Royal Agricultural Society's show at Leicester, we mentioned a novel type of petrol engine, known as the "Synchro-Balance" engine, shown by Messrs. Blackstone and Co., Limited, of Stamford, Lincolnshire. This engine, which was the invention of Mr. R. E. Watts, A.M.I.Mech.E., of Messrs. Blackstone's technical staff, had four cylinders of 3-in. bore, with a piston stroke of 4 in., and was rated at 14·4 h.p., but the chief interest in its design centred round the means employed for transforming the reciprocating motion of the pistons into rotary motion of the crankshaft. The mechanism, which is a little difficult to explain in words, or to follow from an ordinary drawing, can best be understood with the aid of a working model, and as such a model forms part of Messrs. Blackstone's exhibit at the British Empire Exhibition, many engineers have doubtless availed themselves of the opportunity provided for examining it there. As, however, the principle employed appears to have some important possibilities, the following description of the system may be of interest to others.

A photograph of the working model referred to above is reproduced in Fig. 1 on this page, but before describing the mechanism we should explain that its object is to secure perfect balance of the moving parts in conjunction with a more even turning moment and a more compact engine than is obtainable with the conventional design. It is claimed that the new arrangement, which is applicable to steam engines, air compressors, pumps, &c., as well as to internal-combustion engines, has several other incidental advantages which will be mentioned later. Referring now to Fig. 2, which is an isometric projection of the mechanism of the model with the cylinders removed, it will be seen that the four pistons are arranged in two pairs along one side of the crankshaft, and not immediately over it, the pistons of each pair being coupled by short connecting-rods to the opposite ends of a rocking lever. The two rocking levers are supported on stationary pins, and projecting laterally from the centre of each of them is a yoke engaging with trunnions formed on a split bush, one of which is fitted on each of the two crankpins. The crankshaft is illustrated separately in Fig. 3, from which it will be seen that the crankpins are inclined in opposite directions at an angle of 37½ deg. with the axis of the crankshaft; only two crankpins, it will be noticed, are required for a four-cylinder engine. Figs. 4 and 5 illustrate the actual arrangement of the 14·4-h.p. engine exhibited at Leicester, Fig. 4 being a longitudinal section through a pair of cylinders and Fig. 5 a transverse section through one cylinder.

Referring again to Fig. 2, and assuming that the cylinder on the extreme left has fired and that the piston is descending on its working stroke, it will be understood that the force will be transmitted through the rocking lever and yoke to the trunnions, so that a downward pressure will be exerted by the bush on the outer end of the crankpin and an upward pressure on the inner end. Since the ends of the crankpin are on opposite sides of the crankshaft axis, as shown in Fig. 3, a couple will be produced about the latter which will cause the crankshaft to rotate in a clockwise direction, as viewed from the end remote from the flywheel. The action of the other cylinders, firing in turn, will, of course, be similar so that they need not be considered individually.

From the above explanation of the arrangement of the working parts it will be understood that as the angularity of the connecting rods is reduced to a minimum, side thrust from the pistons on the cylinder walls is practically eliminated, and, moreover, since the reciprocating parts are travelling with the same velocity, but in opposite directions, at all parts of the stroke, the inertia forces are balanced out; this applies also to the rocking levers and yokes. The makers claim that, in consequence of this feature, the running is particularly smooth and free from vibration at high speeds, so that it should be possible to construct a "Synchro-Balance" engine which would be smaller, lighter and cheaper for a given power, than an engine of the usual design. It will be obvious that any multiple of four cylinders can be arranged in groups on one side, or on both sides, of the crankshaft, the latter arrangement particularly giving the shortness and compactness which are desirable in engines for marine propulsion; the comparatively small headroom required for the "Synchro-Balance" engine will be apparent from the photograph of the model reproduced in Fig. 1. Other points in favour of the system arise from the fact that the crankshaft is not immediately below the cylinders, so that the former is more accessible, and it is a comparatively easy matter to prevent the used lubricating oil and carbonaceous matter from the cylinders from contaminating the crankshaft lubricating oil; the latter may also be of a lighter grade than is used for cylinder lubrication. On the whole it will be admitted that this interesting departure from conventional design offers sufficient advantages to warrant its being thoroughly tried out under practical working conditions, this being the only reliable method of appraising the merits of any engineering innovation.

Ambulance Seaplane for British Guiana.—We understand that a new Fairey seaplane has recently been launched for tests at Hamble, near Southampton, the machine having been constructed for service in British Guiana. It has been specially designed for a private company in that country, who intend to employ it mainly to convey patients who contract fever on the plantations to the nearest township for treatment. This, at present, involves a journey of about 200 miles by river, and as the latter includes numerous rapids in its course, the patients have to be carried by porters over a considerable part of the distance. The journey thus occupies about 17 days, and it is therefore by no means surprising that many of the patients have succumbed *en route*. The seaplane, however, will enable the journey to be completed in just over two hours, so that by enabling skilled medical treatment to be applied promptly, it should be the means of saving many lives. A wireless installation on the seaplane, supplied by Marconi's Wireless Telegraph Company, Limited, will enable telegraphic and telephonic communication to be maintained with both ends of the route while the machine is in flight, and a special ground station has been erected on the estates for use in connection with the seaplane service.

REFRIGERATING MACHINES AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. L. STERNE AND CO., LIMITED, ENGINEERS, GLASGOW.

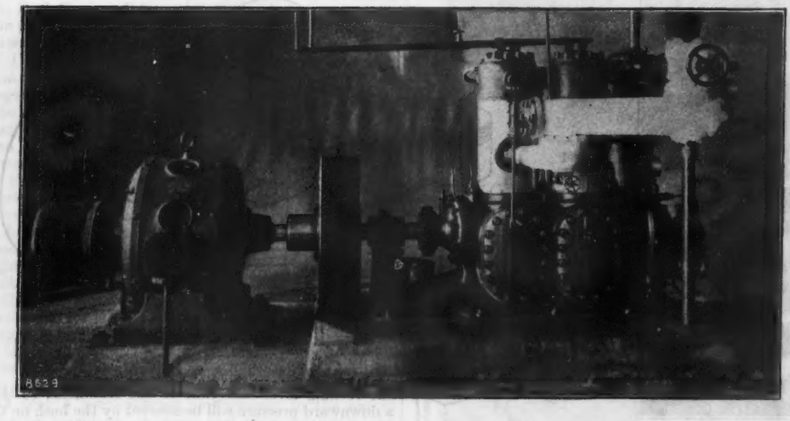


Fig. 19.

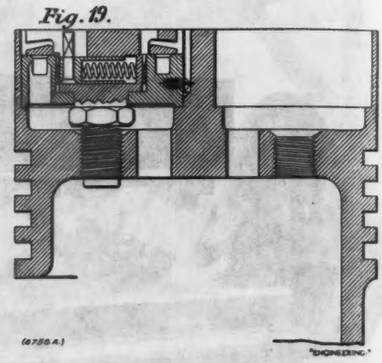


Fig. 18.

REFRIGERATING MACHINES AT THE BRITISH EMPIRE EXHIBITION.

(*Concluded from page 562.*)

Messrs. L. Sterne and Co., Limited, of the Crown Iron Works, Glasgow, show a selection of their refrigerating machines. Of these we have chosen for illustration (see Fig. 18) the three-cylinder, motor-driven high-speed ammonia compressor used with the firm's 20-ton marine refrigerating plants.

In essentials this compressor is identical in construction with that illustrated and described in our issue of January 11, 1924, page 42. The compressor pistons are long trunks fitted with packing rings top and bottom. Large ports are formed in the intermediate length of the trunk, and through these communication is established between the interior of the trunk and the suction ports in the cylinder walls. The suction valves are mounted in the piston head, and in the details of these valves the machine shown at Wembley differs from that described in our previous issue (*loc. cit. supra*). The new arrangement will be readily understood on reference to Figs. 19 to 26. The object aimed at has been to facilitate the use of hardened steel for all the wearing parts, and to make the valves readily removable and replaceable, whilst ensuring their absolute security against coming loose, under the vibrations inseparable from high-speed work. As now made, a valve about 2½ in. in diameter at the discharge edge is used for all sizes of compressor. The number fitted being increased in accordance with the size of the machine.

In Fig. 19 one of these valves is shown in place. The valve seat is bedded by grinding, but is otherwise a loose fit in its hole. It is prevented from turning in the latter by a set-screw, the head of which fits into a slot, as indicated in Fig. 19. It is held down in its place by a screwed extension of the valve guard, as shown, and this screw is prevented from slacking by a spring-actuated pawl which engages with internal-ratchet teeth cut in the metal of the valve seat. The details will be most easily gathered from Figs. 20 to 26. In these the valve guard is shown separately in Figs. 20, 21 and 22. The horizontal hole shown in Fig. 20 takes the cylindrical pawl, which is represented in Figs. 23 and 24. The ⅜-in. hole at the back of this pawl accommodates the spring which holds the pawl up to its work. The projection shown on the upper surface of the pawl fits into the long slot $\frac{1}{8}$ in. wide, which can be seen in Fig. 21. This slot is turned through a right angle at its inner end, and when the projecting stud of the pawl is turned back into this recess, the pawl is held back out of engagement.

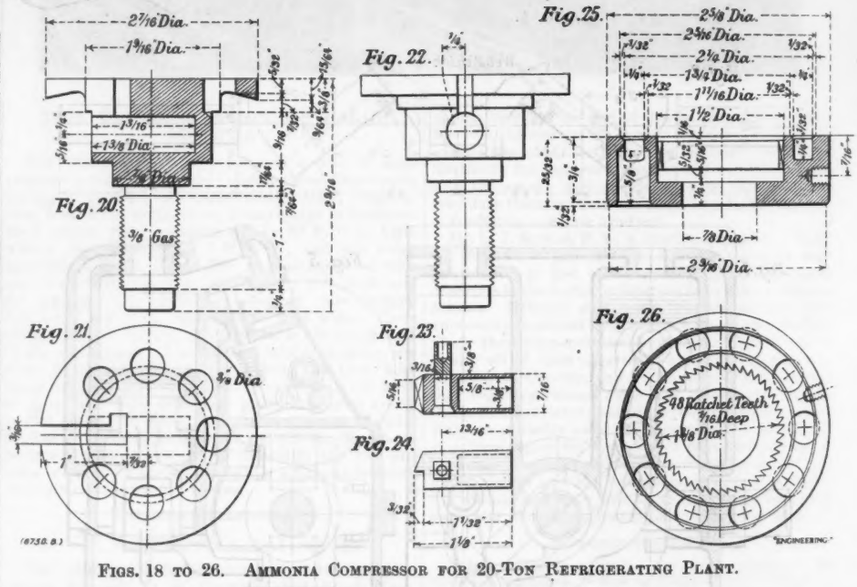
Views of the valve seat are reproduced in Figs. 25 and 26, and show clearly the internal ratchet teeth with which the pawl carried by the guard engages. Hence, once the guard is screwed down, the valve seat is firmly fixed without the possibility of getting loose. To remove it, when required, however, it is only necessary to slide back the pawl until the projecting stud on it can be turned into the rectangular recess at the bottom of the groove on the guard plate.

The nut shown below the valve seat in Fig. 19 merely serves to keep the components together, and is now made knurled instead of hexagonal, as it was found impracticable with the latter form to prevent the fitter getting a spanner on to it and screwing it up so tight as to give rise to difficulties in taking the components apart.

The actual valve is a light steel ring, having the section shown in Fig. 19. The valve seat and guard are all hardened, and will thus work for a very long time without appreciable wear. The lift is small, but as both the inner and outer edges of the ring are available for flow, the effective opening is nearly twice as great as it would be with an ordinary mushroom valve having the same lift.

The machine is provided with forced lubrication throughout.

The firm have also on view a CO_2 machine, and other exhibits include condensers, valves and pipe fittings, many being sectioned so as to show clearly important details of construction.



Figs. 18 to 26. Ammonia Compressor for 20-Ton Refrigerating Plant.

NOTES ON NEW BOOKS.

Mr. Wilhelm Thiemann's "*Uebersee-Maschinenhandel*" [Berlin Julius Springer; price 2·65 dols.] is an economic study of the oversea trade in engines and machinery, and of the inter-relations between the trade and the technics of engineering. As chief of the engine export department of Messrs. Simon, Evers and Company, of Hamburg, Mr. Thiemann has come to the conclusion that exporters and importers generally, do not understand one another, and that the old secrecy policy, which has gone overboard in many technical works, should profitably be abandoned, also in the counting houses. From this point of view, he discusses demand and supply, production, card systems, direct and indirect distribution, propaganda, prices, trusts, trade organisation by banks, government interference, the relations between producers and their agents, and the agents or brokers and customers abroad. He has little belief in statistics because custom houses of different countries have very different ideas as to what constitutes a machine, and for other reasons. The subject is not of interest to everybody, but seems worth the 248 pages devoted to it.

Among the most annoying, as they are among the most common effects encountered in engineering practice, are the phenomena arising from vibration of machinery. In many cases these are regarded as the inevitable consequences of unbalanced parts, and their causes are seldom analysed and their remedy seldom sought. In a little book entitled "*Vibration in Engineering*," published in the Reconstructive Technical Series (published by Messrs. MacDonald and Evans, London, price 7*s.* 6*d.* net), Messrs. Julius Frith and Frederick Buckingham have attempted to investigate the laws of vibration and the character of the motion which results from the various arrangement of mass and the action of restoring forces. They have been induced to undertake this research owing to the scarcity of literature on the subject and its scattered distribution, which make consultation and reference difficult. Perhaps, too, the increased use of heavy rotating parts and the greater accuracy of construction, tending to magnify the effects of resonance by reducing friction, have forced the annoyance into more prominent notice. The authors' treatise is an admirable introduction to the study of the conditions that produce vibration, it is not exhaustive, but it reproduces the theory that guides investigation and indicates the

GARDNER OIL ENGINES AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. NORRIS, HENTY AND GARDNERS, LIMITED, ENGINEERS, MANCHESTER.

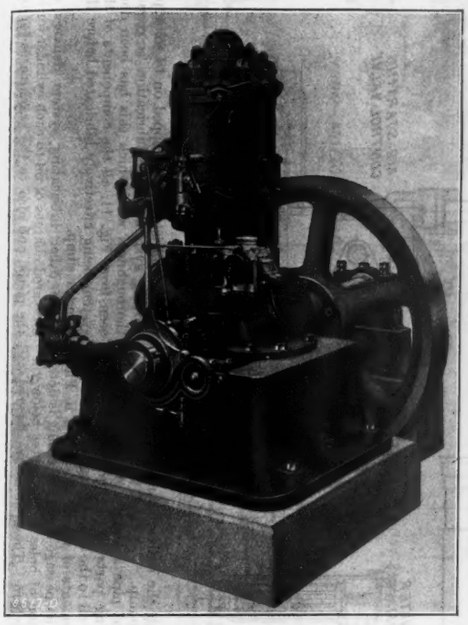


Fig. 1. 18-B.H.P. Two-Cycle Stationary Oil Engine.

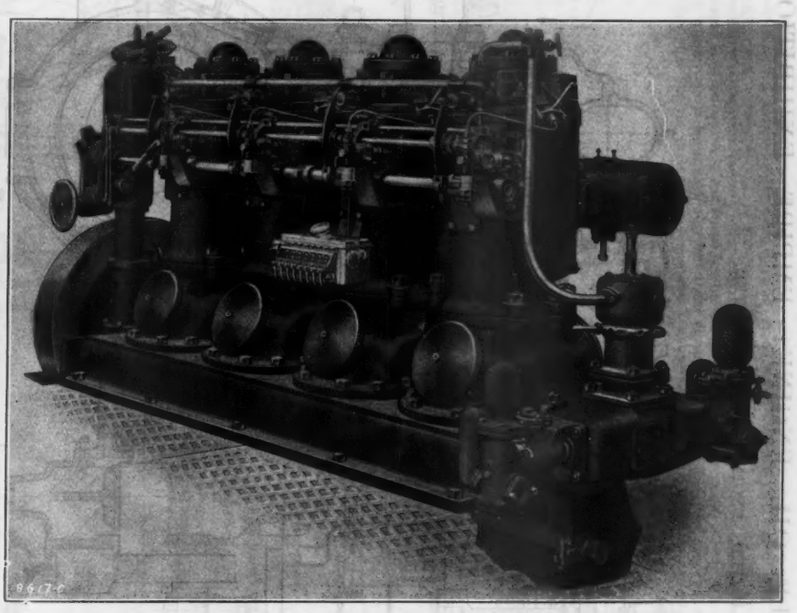


Fig. 2. 96-B.H.P. Marine-Type Two-Cycle Oil Engine.

method of application in some particular instances. The book is divided into two parts, in the former the mechanism of the phenomena is explained and illustrated, the authors claiming that their method of treatment removes many difficulties and simplifies the general problem of forced transverse vibrations of a system with a natural frequency, under the disturbing effect of a force having a variable frequency. The subject of resonance, seeing how widespread are its effects, might have been more fully described and the practical methods of damping vibrations deserve more attention; on the other hand, the examination of the effect of cyclic speed variation on alternators is both novel and informing. Mention is made of an instrument akin to a form of seismograph for measuring the amplitude and quality of vibration; it seems to be a very useful tool, but directions might have been given for deriving the phase and amplitude of the harmonics contained in the general curve. The mathematical treatment of the second part is of a fundamental character, directed mainly to the solution of particular problems. The application of the formulæ to the practical case of a turbine shaft carrying concentrated loads, variously supported, forms a suggestive exercise.

GARDNER HEAVY-OIL ENGINES.

Two examples of oil engines of the hot-bulb type, made by Messrs. Norris, Henty and Gardners, Limited, of Barton Hall Engine Works, Patricroft, Manchester, are illustrated on this page. These engines form part of the exhibit of the firm in the Palace of Engineering of the British Empire Exhibition. In order that the features of the larger engine may be better appreciated, further illustrations are provided of the details of its construction in Figs. 3 to 10 on page 596 and Figs. 11 to 37 on page 597.

The first example, Fig. 1, is a stationary single-cylinder engine, which runs at 400 revolutions per minute and is designed to give 18 brake horse-power. The bore of the cylinder is 8½ in., while the stroke is 9½ in. This engine works on the two-stroke cycle, in which a charge of air is drawn into the crank-case and is later forced under pressure into the cylinder. After compression the air occupies the top part of the cylinder and a small dome, which is not jacketed but is maintained at a black-hot temperature. Just prior to the completion of the compression the oil is injected into the combustion chamber in the form of a spray, and is ignited by contact with the hot dome. At the end of the expansion stroke the piston uncovers ports in the cylinder walls to permit the exhaust of the gases.

The engine bed carries the main bearings, and in it is formed the lower part of the crank-case. Over this the upper part of the crank-case is bolted. In this there are two inspection doors, in which are the air valves and inlet-air silencers. As the crank-case is used for the initial compression of the air, effective arrangements must be made to prevent air leaks near the bearings. The arrangement consists of spring-loaded, sealing washers which are positively driven from the crank webs. Inspection of the bearings, without disturbing the structure of the engine, is made possible by the use of easily removed caps and shells. The crankshaft is made from a solid-steel forging and is provided with balance weights. Little need be said at present about the construction of the cylinder breech, dome and sprayer, for they are similar in general construction to those of the larger engine, which will be referred to later in association with their accompanying illustrations. For the circulation of the cooling water through the cylinder jackets a single-acting ram pump is used, which is driven by an eccentric on the crankshaft. Lubrication of the main bearings is effected by ring oilers, but the crank-pin, cylinder, and gudgeon-pin receive their supplies of oil from a mechanical lubricator. A centrifugal oiler is used to force the oil to the crank-pin, and from there it passes through the interior of the hollow connecting rod to the gudgeon-pin. The fuel pump accurately supplies the requirements of the engine to meet its momentary load, and forces the fuel oil under high pressure to the fuel-injection sprayer. The change in the volume supplied is effected by the governor, which interposes, to a greater or less extent, a hard-steel wedge between the pump ram and the rocking lever from which the ram receives its motion. The pump valves are simple steel balls carried in housings which are detachable. Stationary engines of this type with single cylinders are produced in five standard sizes of from 11½ to 35 b.h.p., and with two cylinders in three sizes of from 24 to 48 b.h.p.

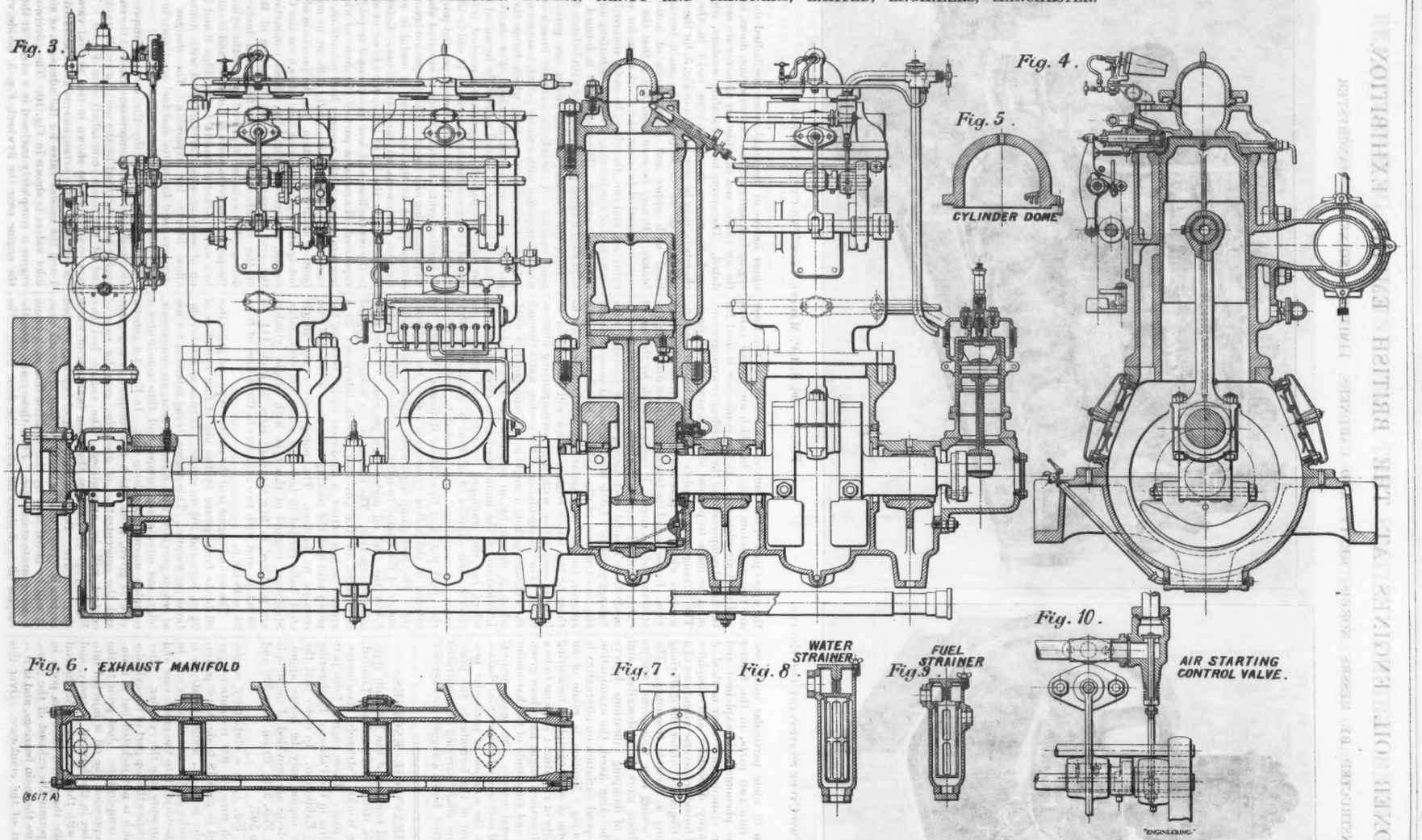
The second engine is of the marine type and generates 96 brake horse-power by the use of four cylinders of 9½ in. bore and 10¾ in. stroke. It runs at 370 revolutions per minute. This engine, being intended for use at sea, is provided with reversing gear, air compressor, bilge and circulating pumps, and thus constitutes a complete marine propulsion unit. In Fig. 2 a general view is given, from which the compact arrangement and the concentration of operating gear for ease of control will be appreciated. The engine bed (see Fig. 3, page 596) carries the main bearings, of which there are five. Between each pair of bearings the bed casting is formed to give the lower half of a crank-case. It will be noted that by this construction each crank has a separate crank-case. From these crank-cases the surplus oil is drained off above the floor level. The upper halves of the crank-cases are bolted on to the engine bed, and each has two inspection doors, in which the air valves and the inlet air silencers are accommodated. The spring-loaded sealing washers, which are used to ensure freedom from leaks in the crank chambers, may be seen in place in Fig. 3, for the cylinder which is shown in section. The main bearings are lined with upper and lower shells of anti-friction bronze. It may be seen from Fig. 3 that the bearing caps are located between the crank-cases for adjacent cylinders, and can, therefore, be easily removed for the inspection of the bearings without disturbing any other part of the engine. The crankshaft is formed from a solid steel forging and is provided with balance weights.

Both the cylinder and its jacket are parts of the same casting. A detachable cylinder breech or head, which is provided with a water jacket, is surmounted by a light, dome-shaped casting, which forms the upper part of the combustion chamber. For starting purposes this dome is heated externally by an oil burner, but once the desired temperature is reached, it is maintained by the combustion process. It will be observed that the dome (Fig. 5) has a small, pointed projection, or ignition grid, within it, which is situated above the jet of incoming oil vapour. This projection becomes the hottest point in the dome and is useful in ensuring ignition when weak mixtures are in use. Later it will be shown how the jet of the sprayer is set at an angle to the centre line, and how this is used to project the vaporised oil against a part of the dome of which the temperature suits the average load conditions. When loads are very low it is usually difficult to make the ignition absolutely certain, but the provision of a very hot ignition grid, such as that shown on the Gardner engine, removes the difficulty. Heat conduction from the grid is restricted by the reduction of the area of the metal uniting it to the main body of the dome. The exhaust is passed out of the cylinders as the piston uncovers ports in the walls and is conducted to a water-jacketed manifold pipe (Figs. 6 and 7), built up of sections which are provided with joints which allow liberty for expansion. The designs of the strainers used for water and fuel are shown in Figs. 8 and 9 respectively.

Starting is effected by the use of compressed air obtained from an air compressor fitted at the end of the engine and operated by the use of a small crank on the end of the main crankshaft, see Fig. 3. The air pipe system is also shown in this general view, while the air inlet valve arrangements are illustrated in Fig. 4 and the master valve for the admission of air to the inlet valves is shown in Fig. 10. The governor of the engine is completely enclosed in a casing at the end of the engine near the flywheel, Fig. 3, beside which all

DETAILS OF 96-B.H.P. GARDNER MARINE-TYPE TWO-CYCLE OIL ENGINE: EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. NORRIS, HENTY AND GARDNERS, LIMITED, ENGINEERS, MANCHESTER.



the controls are concentrated. This centrifugal governor, as well as the camshaft, a multipoint lubricator, and the reversing gear all receive motion from a vertical countershaft, Fig. 11, page 597, which is driven through helical gears by the crankshaft. On the casing of this vertical shaft a small lubrication ram pump is situated, the details of which are shown in Figs. 27 and 28. Whatever pulsations are created in the supply of lubricating oil by the action of the pump, are damped out by an air chamber on the suction side and an anti-pulsator valve on the delivery side, which also serves to control the pressure in the system. This pump is used to supply a "flow and return" system for the crankshaft bearings and the other important parts external to the crank-cases and cylinders. A continuous and copious supply of oil under pressure is passed from the pump to a service pipe, which distributes it to each element. All oil, so dealt with, passes back through the individual crank-cases to the sump beneath the pump.

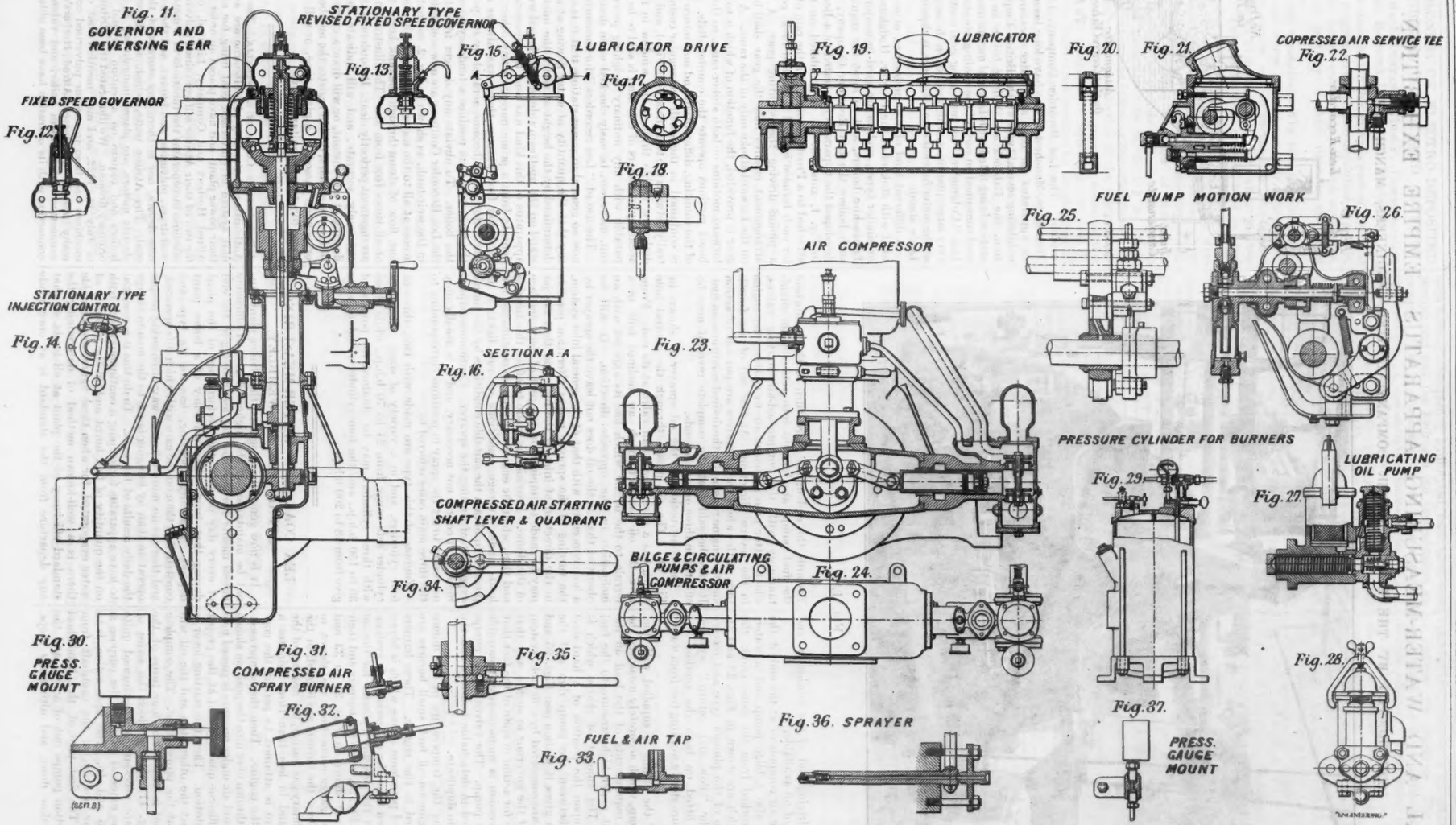
From the general pipe a supply of oil is taken to lubricate all moving parts of the governor system. A pipe conveys the oil to the top of the governor casing, alternative arrangements of which are shown in Figs. 11, 12 and 13, and its passage down the casing is determined by the position of holes in the plates below the governor and elsewhere. These holes are located so that the oil is always dropped on to some part of the moving system, where lubrication is required. The thoroughness with which this has been done can be seen from Fig. 11, all the components of the moving system being effectively lubricated before the oil falls into the sump.

The other lubricating system delivers accurately measured charges of oil to each cylinder for lubricating the piston and also to the crank-cases for feeding the

DETAILS OF 96-B.H.P. GARDNER MARINE-TYPE TWO-CYCLE OIL ENGINE: EMPIRE EXHIBITION.

DETAILS OF 96-B.H.P. GARDNER MARINE-TYPE TWO-CYCLE OIL ENGINE: EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. NORRIS, HENTY AND GARDNERS, LIMITED, ENGINEERS, MANCHESTER.



centrifugal oiler which lubricates the crank and gudgeon pins. This system makes use of a Gardner multi-point lubricator, the details of which are illustrated in Figs. 17 to 21 on this page. For its drive, motion is taken from the camshaft of the engine by means of an eccentric, Fig. 18. This drive is carried through an oscillating clutch case, which houses a clutch of the friction type, Fig. 17, which ensures that the amount of rotation of the lubricator shaft may be regulated at will. Rigidly attached to the camshaft of the lubricator is a handle which can be rotated independent of the driving mechanism, whether the engine is running or not. The construction of the multipoint lubricator may be seen from Figs. 19 and 21. For each lubricating point there are two distinct pumps, one above the other; these are seen in the lower part of Fig. 21. The bottom pump measures the charge of oil and delivers it by a sight feed nozzle into a well, situated above the inlet of the upper pump, into which it flows by gravity and suction. From this pump the measured charge is sent out to the point where it is required. The upper pump has a constant stroke, while the lower one is arranged for a variable stroke, which is controlled by an adjusting screw which projects outside the front of the casing. For examination each double pump may be taken out of the lubricator box. All the sight-feed nozzles are totally enclosed within a chamber provided with a transparent wall. The gauge glass, Fig. 20,

COAL AND WATER-MEASURING APPARATUS; EMPIRE EXHIBITION.

CONSTRUCTED BY THE LEA RECORDER COMPANY, LIMITED, ENGINEERS, MANCHESTER.

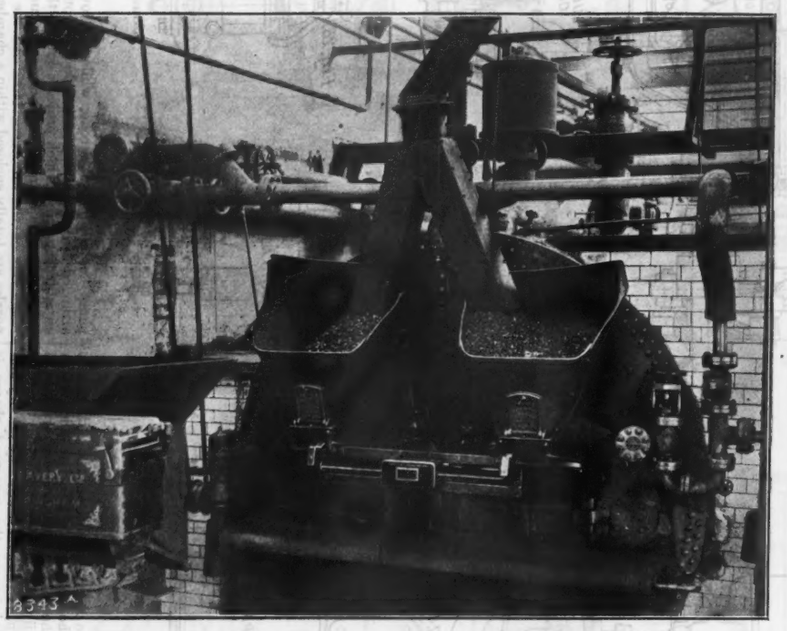
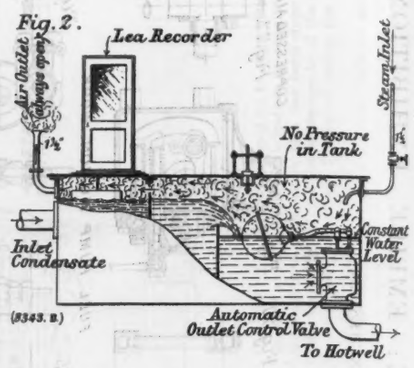


Fig. 1.



is situated at the driving end of the lubricator and shows the quantity of oil available.

In addition to the air compressor at the end of the crankshaft there is also a bilge pump and a water-circulating pump worked from the same crank, the arrangements of which are shown in Figs. 23 and 24. The two pumps are of the plunger type and receive lubrication from the "flow and return" system. Air chambers are fitted on both the suction and delivery sides to ensure steady working free from water-hammer actions.

Each cylinder of the engine is supplied with fuel from a separate pump, which accurately measures the charge to suit the requirements of the load on the engine and forces it under high pressure to the fuel injection sprayer. The amount of charge which is delivered depends upon the position of a hard-steel wedge interposed between the pump ram and the rocking lever which gives it motion (see Figs. 25 and 26). These wedges are connected by a flexible system to the drop links of the governor in such a way that they are always free for action in spite of the fact that each wedge in succession is momentarily immovable while operating the pump. The valves of the pumps are steel balls carried in detachable housings and the delivery valves are in duplicate.

For use in raising the temperature of the domes for starting the engine on oil fuel, small burners are permanently attached to the engine. These burners give a small spray of petroleum across which is blown a current of air taken from the compressed-air system. The construction of the pressure cylinder for the oil burners is shown in Fig. 29, while the burners and their associated fittings are shown in Figs. 31 to 33 and alternative pressure gauge connections are shown in Figs. 30 and 37. Once the burners are lighted, in the same way as an ordinary gas burner, the heating of the domes is started and in less than three minutes a suitable temperature is attained to permit the continued running of the engine. Then the compressed-air starting lever is thrown over into the position shown in Figs. 34 and 35, and air under pressure is passed into the cylinders in sufficient quantity and at the proper periods to cause rotation. Then the starting lever is turned down against the other stop and the oil will then be admitted at the proper time. The complete operation of reversal is effected in four turns of the handwheel (see Fig. 11), during which the series of operations which are necessary are performed quite automatically. The external gear for the purpose is shown in Figs. 15 and 16. The first action is to change the angular position of the camshaft from ahead to astern. The first turn of the handwheel puts the fuel injection pumps out of action and the engine begins to slow down and ultimately stops. Towards the end of the third turn of the handwheel the fuel pumps are brought into action again simultaneously with the compressed-air starting valves, which latter give sufficient air to re-start the engine in the reverse direction. At the end of the fourth turn of the wheel the air valves are put out of action and the engine runs under the desired conditions on fuel. It may be said that the complete reversal may be effected in three or four seconds.

The construction of the oil sprayer is shown in Fig. 36. The oil passes through the central hole which has a spring held ball valve at its end. From here the oil passes through an inclined hole in a ferrule to the nozzle which has its axis set with an inclination in the opposite direction. It will be observed that as the oil does not leave the sprayer by a hole concentric with that of the general inlet system, the turning of the sprayer makes alteration possible in the direction of inlet of the fuel, and thus the jet may be made to impinge on any part of the inner face of the dome. Provision is made to effect this turning and thus, when the engine is to run on continuous full load, under average conditions or run light, it is possible to obtain the suitable conditions by the simple expedient of turning the sprayer. Continuous adjustment is of course not necessary, and it is usually only necessary to set the spray in positions corresponding to the three main cases referred to.

Engines of this type are made with two, three or four cylinders, and in a variety of sizes. The two-cylinder sets range from 24 to 70 b.h.p., while those with three cylinders may be obtained for powers of 36 to 150 b.h.p., and the four-cylinder standard sizes give from 48 to 200 b.h.p.

LEA COAL AND WATER-MEASURING APPARATUS AT WEMBLEY.

It is now generally recognised that boiler plant cannot be maintained at the highest degree of efficiency unless means are provided for ascertaining at the end of every day or shift the performance of the plant during that time. The efficiency of a boiler plant depends, generally speaking, less on its type and construction than on the care with which it is operated, and there is no more effective way of ensuring proper operation than by bringing home to the man in charge the daily results of his work. To do this it is essential to have apparatus for keeping a continuous check both on the quantity of fuel burnt and on the quantity of water evaporated, for when these figures are available there is a well-known method of determining the standard efficiency of the plant at all loads, so that any departure from the standard is at once made evident. The Lea Recorder Company, Ltd., of 28, Deansgate, Manchester, who have long been specialists in apparatus for coal and water measurement, are exhibiting several types at the British Empire Exhibition, the Babcock and Wilcox boilers in the power station being fitted with Lea coal meters measuring the coal consumed on each of the chain-grate stokers. The Lea "Cubimeter" for measuring coal continuously in very large quantities, which works on the same principle as the meter for chain grate stokers, is shown on Messrs. Lea's stand.

A different kind of coal meter has, of course, to be used with stokers of the Proctor, Hodgkinson, Bennis or similar types, such as are used in conjunction with Lancashire boilers, and to meet the requirements of such boilers the Lea Recorder Company, Ltd., have developed the apparatus illustrated on a Bennis stoker in Fig. 1, annexed. It is exhibited on their stand attached to a Proctor stoker. On the ram of the stoker for each furnace is fixed a toothed rack, gearing with a pinion driving the counting gear. A non-return arrangement ensures that the gear shall be operated on the forward stroke only of the rams. A differential gear is provided, the function of which is to add up the forward motions of both stoker-rams, so that the combined motions operate the counter dials. The whole of the counting, differential, and non-return mechanism is contained in the small rectangular casing seen centrally between the two furnaces in Fig. 1, and the counter dials are visible through the window in front. The accuracy of meters of this kind is said to be quite comparable with any ordinary weighing process, and it can, moreover, be easly checked when desired.

The use of "Lea recorders" for measuring water is now so general in power stations that it is sufficient to say that the quantity of water flowing at any time is determined by the height at which the inlet water will stand on the upstream side of a V-shaped weir. When apparatus of this kind was used for measuring the condensate from a prime mover or any other water used for boiler feed purpose there was always a fear that the water might become aerated by its passage over the weir, and thus produce a tendency to corrosion in the boiler. To obviate any danger from this source, the Lea Recorder Company are now completely closing-in the weir-tank, as shown in Fig. 2, so that air has no access at all to the water. A very slight, but continuous, flow of steam through the tank keeps the interior at all times free from air. The illustration makes the arrangement perfectly clear. Recorders of this kind are extremely accurate, and will indicate the quantity flowing at any instant, or will draw a curve of the rate of flow on a chart, or will register the number of gallons or pounds passed in a given time, or will perform all these functions simultaneously.

Pulverised Coal in Australia.—The Electricity Authorities of the City of Melbourne are adopting the unit system of pulverised coal firing for extensions to their power plant, and have placed an order with Messrs. Alfred Herbert and Company, Limited, of Coventry, for two of their Atritor self-contained pulverisers. Each machine incorporates the functions of a metal separator, coal dryer, pulveriser and blower, and there are no separate dryers, nor is there any storage of the powdered coal. The Atritor units, which are driven direct by electric motors, are placed immediately in front of the boilers and require no attention beyond that of the ordinary fireman. We illustrated the Atritor in our issue of July 14, 1922, and may mention that one of these machines has been in use for pulverised coal firing for many months at Messrs. Alfred Herbert's works, in connection with a steam boiler, and valuable data in connection with its operation have been obtained.

THE HARDNESS OF ELECTRO-DEPOSITED IRON, NICKEL, COBALT AND COPPER.*

By D. J. MACNAUGHTAN, A.Inst.P. (Communication from the Research Department, Woolwich).

THE work described in this paper is part of a general research in progress on the electro-deposition of metals, in which the factors controlling adhesion, soundness, strength and ductility of thick deposits are being investigated.

Experimental Conditions.—The following conditions applied except where otherwise stated. The experiments were carried out in rectangular glass tanks 12 in. by 8 in. by 15 in. deep, containing about 15 litres of solution. Two anodes 9 in. by 6 in. by ⅜ in., and in certain cases four anodes, were placed so as to be about 3½ in. from the cathode. The cathodes were cylindrical steel rods 1 in. in diameter, having about 6 in. of their length immersed during deposition. Conditions were arranged to allow of continuous deposition over lengthy periods of time. The deposits obtained were generally 0·08 in. to 0·1 in. thick. For most of the tests the following restricted conditions were imposed: (*a*) non-agitation of the electrolyte—only occasional stirring to prevent concentration changes; (*b*) no temperature higher than 40 deg. C., since this is the limit of temperature for the stopping-off waxes used under commercial conditions.

The cathodes, after deposition, were cut transversely so as to provide suitable specimens for hardness tests and for micro-examination. The Brinell hardness of the edge and face of the deposit was determined, a ball of 1 millimetre diameter and a load of 30 kilogrammes being used. The acidity and metal content of the solutions were estimated by the usual methods. The hydrogen ion concentration, which proved to be of great importance in connection with the deposition of iron, nickel and cobalt, was obtained by the use of a series of coloured indicators, in a manner similar to that of Thompson.

Copper Deposits.—Steel cathodes were given a preliminary thin coating of copper in a hot cyanide bath. Thick deposits were then formed under the conditions shown in Table I., which also shows their Brinell hardness.

TABLE I.—*Copper Deposits.*

Electrolyte, 175 grammes copper sulphate, $CuSO_4 5H_2O$, 25 ,, sulphuric acid } per litre
Temperature, 22° C. Average thickness of deposit, 0·05 in.

No.	Current Density Amperes per sq. ft.	Brinell Hardness Number.	Remarks.
A	5	58	Tough
B	10	60	,,
C	15	63	,,
D	20	66	,,

It is evident that with increase in current density there is an increase in Brinell hardness. In accord with Bancroft's axioms, with increase of current density there is a decrease in crystal size. With the highest current density employed there is pronounced twinning. Similar examples of twinning have been obtained by other workers.

The hardness of the deposits is not considerable, being only intermediate between that of annealed copper and of hard-rolled copper. The Brinell hardness number range (58–66) shows that such deposits are unsuitable for the coating of surfacers which are to be exposed to severe wear. This was found to be the case by users of copper electrotypes as long ago as 1840. In 1841 Boettger suggested coating such electrotypes with a layer of electro-deposited iron, and it was found that, as a result of the superior hardness of the iron deposit, a great increase in life was obtained.

Deposition of Iron, Nickel and Cobalt.—To secure satisfactory deposits of these metals it is necessary to maintain the hydrogen concentration as low as possible, without, however, being so low as to involve the risk of precipitation of basic salts in the deposit. Thus, in general, the solutions used are maintained just slightly acid. In spite of the low acidity, however, a certain amount of hydrogen is usually co-deposited with the metal—a complication which does not occur at all in the case of copper deposited from the highly acid solution used.

Iron Deposits.—Anodes consisting of plates of Armco iron were used with an electrolyte containing 75 grammes ferrous ammonium sulphate per litre, except where otherwise stated. (*a*) *Effect of Hydrogen Ion Concentration.*—When freshly made up, without any acid additions, the solution was found to have a hydrogen ion concentration of *p*H 4·5. Upon exposure to the air the solution readily oxidised, the ferric salts formed subsequently hydrolysed, basic salts were precipitated and the hydrogen ion concentration increased. Thus, in one case after 168 hours exposure, the hydrogen ion concentration increased to *p*H 2·5. In determining the effect of such changes of hydrogen ion concentration upon the quality of the deposits, the metal content of the bath, however, being kept constant, solutions were used having different degrees of acidity. The acidity was kept as constant as possible throughout the period of deposition, in certain cases by frequent additions of acid. The hydrogen ion concentration was determined at frequent intervals using as indicators brom-phenyl blue, brom-cresol purple, and methyl red. The results of these experiments are shown in Table II.

TABLE II.—*Iron Deposits—Effect of Hydrogen Ion Concentration.*

Electrolyte, 75 grammes ferrous ammonium sulphate per litre: the acidity was controlled by the addition of sulphuric acid.
Current density, 4·7 amperes per sq. ft.
Potential difference, 0·54 to 0·68 volt.
Temperature, 18 deg. to 22 deg. C. Average thickness of deposit, 0·88 in.

No.	Hydrogen Ion Concentration, *p*H Range.	Brinell Hardness Number.	Remarks.
34A	4·5 to 4·2	167	Tough, with matt surface; pitted.
38A	,, ,,	195	
77A	,, ,,	174	
45A	3·6 to 3·8	229	Brittle, with smooth surface; not pitted.
46A	,, ,,	232	
48A	,, ,,	225	
57A	,, ,,	239	
56A	,, ,,	244	
55A	,, ,,	244	
39A	3·3 to 3·5	275	All except 40A were fairly tough; 40A was very brittle. Surface smooth generally, but somewhat eroded.
40A	,, ,,	281	
62A	,, ,,	256	
63A	,, ,,	263	

It is evident that variations in acidity, such as might occur as a result of oxidation of the solution, have a marked effect on the Brinell hardness of the deposits. The general effect of an increase in acidity (within the limits studied) is to cause an increase in hardness over a range of 160–280 Brinell number. It has been found in practice that the most constant conditions of depositions are obtained in the above electrolyte if a certain amount of ferrous carbonate is added. An experimental study of the effect of this addition showed that it secured a low hydrogen ion concentration of about 5·5 to 5·7 *p*H, which remained constant over lengthy periods, if the ferrous carbonate was kept in suspension by occasional stirring. The Brinell hardness number of a deposit obtained from such a solution was about 140. This deposit was fairly tough. (*b*) *Effect of Current Density, Temperature, &c.*—The current density used throughout the above experiments (4·7 amperes per square foot) is low and involves a slow rate of deposition. Increasing the rate of 7·5 amperes per square foot, without agitation, resulted in powdery deposits. Higher current densities can, however, be secured with the use of a more highly-concentrated solution of ferrous ammonium sulphate. Thus, with a solution containing 350 grammes of this salt per litre it is possible to use a current density of 20 amperes per square foot. The effect of current density upon the hardness of deposits obtained from this solution is given in Table III.

TABLE III.—*Iron Deposits—Effect of Current Density.*

Electrolyte, 325 grammes ferrous ammonium sulphate per litre (*p*H 4·4).
Temperature, 19 deg. C. Thickness of deposit, 0·08 in.

No.	Current Density. Amperes per sq. ft.	Potential Difference. Volts.	Brinell Hardness Number	Remarks.
B25	5	0·52	182	Tough. Crystalline surface.
B26	10	0·72	229	Somewhat tough; matt surface.
B24	15	0·96	283	Brittle. Smooth surface.
B22	20	1·26	354	Very brittle. Smooth surface.

An increase in current density from 5 to 20 amperes per square foot caused an increase in Brinell hardness number from 180 to 350. At more elevated temperatures higher rates of deposition can be secured. Thus with the above concentrated ferrous ammonium sulphate solution at 41 deg. C., a current density of 50 amperes per square foot gave a very satisfactory deposit, which had a hardness of about 240 Brinell hardness number. The increased temperature had produced a softening effect which more than counterbalanced the tendency of the greater rate of deposition to increase the hardness. The effect of increased temperature was more particularly studied in ferrous chloride solutions. Thus, using the well-known Langbein-Fischer bath, which is a highly concentrated solution of ferrous chloride and calcium chloride, it was found possible to obtain at 95 deg. C., at the high current density of 100 amperes per square foot, satisfactory deposits having a Brinell hardness number as low as 180. Increasing the acidity of a hot ferrous chloride solution was found to increase the hardness of the deposit greatly. Thus, in the case of a fairly concentrated solution of ferrous chloride at 36 deg. C. a deposit of 199 Brinell hardness number was obtained at a current density of 50 amperes per square foot. Upon increasing the acidity of this solution the hardness of the deposit under otherwise similar conditions rose to 344 Brinell hardness number.

Table IV shows the results obtained in ferrous chloride solution.

TABLE IV.—*Iron Deposits—Effect of Temperature and Acidity of Solution.*

Electrolyte, 460 grammes ferrous chloride per litre. Temperature, 36 deg. to 40 deg. C.
Average thickness of deposit, 0·09 in. Average potential difference, 1·11 volt.
Current density, 50 amperes per sq. ft.

No.	Acidity.	Brinell Hardness Number.	Remarks.
51A	No acid added	199	Fairly tough. Matt surface.
51B	0·002–0·003 N HCl	278	Smooth surface (with a few growths). Brittle.
67A	,,	339	
67B	,,	295	
52A	,,	344	

(*c*) *Microstructure.*—A series of deposits were made ranging from 140 to 354 Brinell hardness number. The softer deposits show well-defined crystals, which become smaller in size as the hardness of the deposits increases, and ultimately in the hardest deposits form an exceedingly fine structure which cannot satisfactorily be resolved under the microscope. (*d*) *Summary of Results. Iron Deposits.*—The results obtained suggest that hydrogen ion concentration and increase in current density tend to harden the deposits, whereas increase in temperature of deposition tends to soften the deposits. Thus by the judicious adjustment of these factors iron deposits may be obtained of various degrees of hardness ranging from 140 to 360 Brinell hardness number. It further appears that the hardness is associated with fineness of crystalline structure.

Nickel Deposits.—When a solution of nickel ammonium sulphate is used as an electrolyte the maximum possible concentration is about 100 grammes per litre, involving a low metal content. It has, therefore, been considered that only a comparatively low current, density, without agitation of the solution is allowable. During recent years solutions containing nickel sulphate which has a much greater solubility, have become popular, and there is a tendency to discontinue the use of the double salt. In the course of this investigation it has appeared, however, that nickel ammonium sulphate solutions are very suitable for obtaining extremely hard deposits, and that with suitable preliminary cleaning of steel surfaces deposits of considerable thickness can readily be obtained upon steel at reasonably high current densities. It is usual in solutions containing nickel sulphate to employ boric acid as the chief source of hydrogen ions. It has been found in this investigation that the hardness of the deposits obtained from such solutions may vary between wide limits. The results given above were obtained with a solution of high nickel content containing boric acid (Table V), and solutions with

TABLE V.—*Nickel Deposits.*

Electrolyte, 240 grammes nickel sulphate (crystal), 15 ,, sodium chloride, 30 ,, boric acid } per litre.
Temperature, 18 deg. to 22 deg. C. Average thickness of deposit 0·08 in.
Potential difference, 1·01 to 2·2 volts.

No.	Hydrogen Ion Concentration, *p*H Range.	Current Density Amperes per sq. ft.	Brinell Hardness Number	Remarks.
N31	6·0 to 5·8	5	181	Very tough, smooth surface.
N32	,, ,,	10	186	
N33	,, ,,	15	217	
N1	,, ,,	20	211	
N3	,, ,,	20	214	
N6	,, ,,	20	210	
N7	Solution increased in acidity, the *p*H changing from 5·8 to 5·3.	20	243	Tough, but less so than the above series. Smooth surface.
N11		20	271	
N10		20	284	
N16A		20	304	

* Abstract of a paper read at the meeting on Friday, May 9, of the Iron and Steel Institute.

low nickel content (*a*) without boric acid (Table VI), and (*b*) with boric acid (Table VII).

It is evident that the hardness of the deposits obtained from the nickel sulphate + boric acid solution (Table V) is distinctly affected by the hydrogen ion concentration. Thus with the same current density between the limits of *p*H 5·8 to 6·0 the Brinell hardness number range of the deposits is 210 to 214, whereas between the limits of 5·3 to 5·8 *p*H the Brinell hardness number range is 243 to 304. The Brinell hardness range of the deposits obtained from the solution of nickel ammonium sulphate without boric acid (Table VI) is very high, and appears to be but little affected by alteration in current density between the limits of 5 and 20 amperes per square foot. The deposits obtained with current densities from 5 to 15 amperes per square foot are satisfactory in appearance and can be readily obtained of considerable thickness. At higher current densities the deposits become increasingly rough and brittle.

TABLE VI.—*Nickel Deposits.*

Electrolyte, 62·5 grammes nickel ammonium sulphate (crystal), 25·0 „ nickel sulphate (crystal), 8·0 „ potassium chloride — per litre.
Temperature, 17 deg. to 21 deg. C. Thickness of deposits, 0·03 to 0·06 in.
Potential difference, 1·4 to 1·95 volt.
Hydrogen on concentration *p*H range, 5·6 to 5·8.

No.	Current Density Amperes per sq. ft.	Brinell Hardness Number	Remarks.
Y4	5	385	Smooth deposits; somewhat brittle.
Y5	10	352	
Y7	10	358	
Y8	10	389	
Y10	10	420	
Y6	15	376	Fairly smooth; somewhat brittle.
Y1	20	387	Rough surface; distinctly brittle.
Y3	20	382	

TABLE VII.—*Nickel Deposits.*

Electrolyte, 75 grammes nickel ammonium sulphate (crystal), 50 „ nickel sulphate (crystal), 25 „ boric acid — per litre.
Temperature, 17 deg. to 19 deg. C. Potential difference, 2·0 to 3·3 volts.
Hydrogen ion concentration, *p*H about 5·8.
Thickness of deposit, 0·05 to 0·06 in.

No.	Current Density Amperes per sq. ft.	Brinell Hardness Number	Remarks.
X7	5	347	Smooth deposits; somewhat brittle.
X12	10	355	
X13	15	347	Rough deposits; distinctly brittle.
X14	10	374	

The Brinell hardness number range of the deposits obtained from the nickel ammonium sulphate solution containing boric acid (Table VII) is high in spite of the presence of boric acid. *Microstructure.*—Deposits were made showing a range of Brinell hardness number from 200 to 420. They present the same characteristics as iron deposits. *Summary of Results. Nickel Deposits.*—The chief factors which determine the hardness of deposits obtained from nickel depositing solutions at ordinary temperature appear to be hydrogen ion concentration and metal ion concentration. Increase of the former, within certain limits, tends to harden, increase of the latter tends to soften the deposits.

Cobalt Deposits.—It is possible with cobalt sulphate to obtain solutions suitable for deposition which have such a high metal content and conductivity as to allow the use of very high current densities at ordinary temperatures. For this reason Kalmus, in spite of the greater cost of cobalt metal, has advocated, on commercial grounds, the substitution of cobalt-plating for nickel-plating. In the absence of quantitative measurements, contradictory views have been held concerning the relative hardness of cobalt and nickel deposits. Probably the most general view is that cobalt deposits are harder than nickel deposits. Although deposits of the former metal have not been considerably studied by the author, it would appear that the range of Brinell hardness is similar to that of deposited nickel. Thus with Kalmus' solution, consisting of 565 grammes cobalt sulphate (crystal), 20 grammes sodium chloride, 30 grammes boric acid per litre, the range of hardness obtained was 270 to 311 Brinell hardness number. This range is not dissimilar from that obtained in the case of nickel deposits from the concentrated nickel sulphate-boric acid bath. The microstructure of a cobalt deposit, having a Brinell hardness of 311, is somewhat similar in appearance to the nickel deposit, which has a nearly equal Brinell hardness number.

Internal Stress in Deposits.—The evidence of internal stress was very marked in the harder deposits of iron, nickel and cobalt. It was indicated by steel strips being bent when plated upon one side by hard deposits of these metals (as described by Stoney in the case of nickel deposits). The deposit was invariably upon the inside of the bend, indicating a condition of tensile stress. Similar tests made with copper deposited under the conditions shown in Table I gave no such definite evidence of internal stress.

The Cause of High Hardness in Electro-deposited Metals.—The analysis and hardness of two typical deposits is shown in Table VIII.

TABLE VIII.

Iron Deposit (No. 59A)			Nickel Deposit (No. N16A).		
Analysis.		Brinell Hardness Number.	Analysis.		Brinell Hardness Number.
Carbon ..	0·023	350	Iron ..	0·07	304
Silicon ..	0·009		Copper ..	<0·01	
Manganese	0·005		Cobalt ..	<0·01	
Sulphur ..	0·003		Manganese	0·06	
Phosphorus	0·004		Carbon ..	trace	

The hardness of these deposits is much greater than could be obtained with iron and nickel, of the composition indicated, by heat treatment or cold-work. At least one impurity, however, is not included in this analysis. Hydrogen was present in both samples, and its effect on hardness must be considered. The absence of hydrogen in soft copper deposits may be significant in this connection.

The view that the high hardness of certain iron deposits is due to hydrogen dissolved as such, or as a hydride, appears to have been adopted by numerous researchers. Lee determined the hydrogen content of a number of iron deposits obtained over a wide range of conditions (including those which this investigation has shown would produce deposits having a Brinell hardness of 350), and his results range from 0·003 per cent. to 0·12 per cent. In a few preliminary determinations made in the course of the present research, the hydrogen content found was much lower than the higher figures given by Lee.

An alternative explanation of the hardness is suggested by the fineness of the crystalline structure of hard deposits. The structures present features the meaning of which is not yet fully understood, but it would appear that the crystals of which they are composed are extremely minute.

Bassett and Davis have determined quantitatively the relation between crystal size and Brinell hardness in *a* brass, cold-worked and recrystallised by annealing at different temperatures, and from these and other results Jeffries has inferred that the hardness of metals would be raised much above that attainable by cold-work if the crystals could be made sufficiently small. Further evidence of this suggestion is required, but it may be that the metal crystals formed under the conditions of electro-deposition which produce hard deposits are so small as to account for the high degree of hardness.

It has been suggested that hydrogen plays a part in the formation of very finely crystalline deposits. Of the hydrogen atoms which are co-deposited with the metal it is probable that a number enter into the space lattice of the deposit forming a solid solution, a number remain at the boundries of the crystals, and a number unite to form molecular hydrogen which subsequently passes off as gas. The deposited hydrogen which does not enter into solid solution may prevent the growth of crystals and result in the continual formation of fresh centres of crystallisation. It would be expected that deposited hydrogen acting in this way would in part be trapped at the crystal boundaries, giving rise to intercrystalline brittleness, the remainder escaping as gas after continuing to form molecular hydrogen.

Unequal distribution of dissolved hydrogen has been proposed by Lee as a possible cause of internal stress in iron deposits. In the case of nickel deposits, the small amounts of hydrogen found to be present suggest that such an explanation is inadequate.

In order to account for the internal stress in nickel deposits, Kohlschutter and Vuilleumier have suggested that the metal is first deposited in a dispersed colloidal condition upon the cathode surface, and that it subsequently changes after a finite interval into the crystalline condition. Assuming that the colloidal condition is largely amorphous, such a change would involve a contraction in volume, which being opposed by cohesive forces at the cathode surface would produce a condition of tensile stress. This view might explain the hardness of deposits if the conversion of the amorphous into the crystalline phase were incomplete. One of the chief difficulties in this theory appears to be that it involves the transformation of amorphous into crystalline metal at atmospheric temperatures. In cold-worked iron, nickel, or cobalt this transformation requires much higher temperatures.

Another suggestion is that the condition of internal stress in deposits may be an effect produced by electrical forces during electrolysis (Faust).

Thus it might be considered possible for displacement of atoms from their normal positions in a space lattice to result from electrical forces acting on them while they are being deposited, causing local deformation or strain of the lattice. The conditions thus produced would resemble those of cold-worked metals, except for the more minute scale on which the deformation would take place. If the deformation is partly elastic and partly permanent, it would explain the state of stress existing in hard deposits as well as their hardness. An objection to this view seems to be that whereas the electrical field exerts an influence upon charged metal ions and thereby causes them to be brought up against the cathode surface, as soon as these ions are neutralised (by electrons from the cathode surface) and become metal atoms there appear to be no established reasons why the influence of the electrical field upon them should be maintained. If this be the case, the only forces influencing the newly formed metal atoms would be the forces of crystallisation and cohesion at the cathode surface.

Summary.—1. The Brinell hardness numbers of the deposits obtained under the conditions described range between the following limits: Copper 58-66; iron 140-360; nickel 180-420; cobalt 270-311.

2. The conditions of deposition which within certain limits have been found to cause increase in hardness are: (*a*) Decrease in temperature (iron deposits); (*b*) increase in current density (copper deposits and iron deposits); (*c*) Decrease in metal ion concentration (nickel deposits); (*d*) Increase in hydrogen ion concentration (iron deposits; nickel deposits).

3. Of these conditions the first three coincide with the factors which, according to Bancroft, cause decrease in the crystal size of deposits; and the fourth (*d*) has been noted by various investigators, such as Hughes (iron deposits) and Thompson (nickel deposits), to favour small crystal size.

4. By the judicious adjustment of the various factors referred to above, the hardness of deposits of iron, nickel and cobalt can be controlled within fairly close limits.

5. Several possible alternative explanations of the high hardness of certain deposits have been discussed. These respectively ascribed the hardness to (*a*) Hydrogen deposited simultaneously with the metal forming a hard solid solution with it. The amount of hydrogen retained in solid solution seems insufficient to account for the high hardness attainable. (*b*) Deposition of the metal largely in the amorphous condition. This is thought to be improbable. (*c*) Displacement of atoms from their normal positions on a crystal lattice by electrical forces acting on them while they are being deposited, resulting in distortion of the crystal lattice growing, with consequent deformation, partly permanent and partly elastic, thereby producing an effect similar to that of cold-work. It does not, however, appear likely that the forces of crystallisation can be affected by the electrical forces involved during deposition. (*d*) The minute size of the crystals of the deposited metal. The deposition of hydrogen with the metal may be one of the factors interfering with crystal growth, and thus reducing the size of the crystals.

PIPES FROM BLAST-FURNACE SLAG.—The Dresler process of making bricks from blast furnace slag has found application on a considerable number of Rhenish iron works. Recently pipes have also been made from the same material and essentially by the same simple, relatively inexpensive process, and the pipes have stood mechanical tests, upon which Dr. F. Riedel has reported to a blast-furnace slag committee of the German iron-masters (Stahl und Eisen, September 24). Like the bricks the pipes are made from ground slag ("meal") and slag sand. As in the production of cement pipes, use is made of two concentric former tubes of sheet iron. The meal and the sand are run in alternating layers into the annular space between the two tubes, and the layers are rammed down separately. The mixture acquires sufficient hardness to allow of withdrawing the tubes; this is done while the pipe lies on a truck, on which it is taken into the kiln, which is a chamber charged with combustion gas drawn from a blast furnace. This gas contains the carbon dioxide wanted to combine with the lime in the slag and thus to harden the pipes (or bricks). The treatment lasts 48 hours, after which the pipes are sufficiently hard for use. In crushing tests Riedel put a saddle of wood on 300 mm. (12 in.) pipes and loaded the saddle with pig-iron. The pipe bore 2,500 kg. without being crushed, which is a high load considering that no binder is used. The greatest risk in the preparation of the pipes is their breaking in the first stage. To reduce this risk the pipes are hardened immediately after removal of the former tubes by passing the gas through the pipe. The pipes are waterproofed by providing them with an inner cement lining; cement pipes themselves require four weeks for their finishing instead of the two days of slag pipes.